THE ENVIRONMENTAL IMPACT ASSESSMENT OF HOSPITAL WASTE INCINERATORS

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Doctor of Philosophy (PhD)

by

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DECLARATIONS

I declare that the study presented in this thesis is the result of my own investigation.

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Salford, April/1993

I declare that this work has under no circumstance been submitted in candidature for any other degree.

Seyed Ali Akbar
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Salford, April/1993

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Abstract

THE ENVIRONMENTAL IMPACT ASSESSMENT OF HOSPITAL WASTE INCINERATORS

This thesis makes a study of the environmental impact of waste incineration and particularly of hospital waste incineration. Literature relevant to the topic is discussed. The environmental impact of the incineration process itself and the different methods used in the disposal of wastes was assessed.

The nature of waste is reviewed in relation to quantities, composition and classification. Legislation concerning hospital waste disposal is summarised.

The study also focuses on methods of waste disposal including the characteristics and nature of incineration, the activities involved in the combustion process of hospital waste and the nature of incinerator stack emissions and the biological material released to the environment. Other methods of disposal are explained. The perceived and inherent risks associated with hospital waste incineration are discussed.

The results of the data collected during this research are presented, analyzed and discussed. The thesis also analyses the link between hospital waste incineration and EIA. In addition the importance of the effects of hospital waste incineration on human health are discussed.

Environmental Impact Assessment (EIA) is discussed including its methodology. The advantages, disadvantages and its use in the UK and Iran are reviewed.

A critique of the Environmental Impact Assessment submitted by Environmental Technology Consultants Ltd. (ETC). for the proposed incinerator at Kirkby is given.

The thesis concludes with a consideration of the application of EIA techniques to planning applications for hospital waste incinerator and makes a number of recommendations as to their use and applicability.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

A proposition to site a waste processing facility in any community often meets with stiff opposition. The opposition often results from anxiety, anxiety which centres on the possibility of being victims of an 'environmental disaster'. The public often perceives such facilities as an environmental hazard.

The prediction of the performance of a hazardous waste project is a difficult process. To alleviate this dilemma, a critical step in the design of a new waste facility would be to employ the most advanced waste management technologies as well as creating newer and improved facilities. Despite the advances made in the improvement of waste management technologies, acquiring sites on which to operate the facilities is an exceptionally difficult task. Although the public is very keen to have hazardous wastes managed properly and safely, nobody wants it managed near them.

Most people do not want hazardous waste incineration facilities in their 'back yards' because of the perceived impacts of such projects. Such 'impacts' include emission from chimneys, noise, traffic, and the perceived impact on property values. Incineration is one method of waste disposal, and this method has become popular over the last ten years and the topic has received more than its fair share of publicity, some of which has been adverse.

It is believed that modern incineration can provide an effective solution to the problems which were created by waste disposal by landfill such as smell, the contamination of water supply, partial damage to large areas of land and the aesthetically objectionable appearance of landfill sites. Incineration reduces the volume of waste and the end product is a sterile ash. Heat recovery may be possible resulting in a considerable saving in fuel costs. Air pollution is, however, a possible major hazard and may lead to environmental and health problems.

1.2 Aims of study

This thesis aims to study the environmental impact of waste incineration and particularly of hospital waste incineration. The study combines a detailed survey of the literature on waste incineration with two case studies in local communities:- that of Kirkby in North West England, and that of the city of Ahwaz in South West Iran. As a result of the above studies a critique of the applications of EIA techniques to hospital waste incineration will be produced.

In my research I hoped to identify the shared concerns of the two communities and to evaluate the public opposition to incinerator schemes. In addition I hoped to make recommendations as to how the environmental impact of such schemes may be reduced.

1.3 Outline

This thesis is divided into 11 chapters. Chapter one, reviews in detail existing literature relevant to this research project. It assesses the incineration process itself and the different methods used in the disposal of wastes. A detailed review of the process of hospital incineration Environmental Impact Assessment and attitudes towards siting a hazardous or hospital incinerator is undertaken.

Chapter two discusses waste in relation to quantities, composition and classification. It includes legislation concerning hospital waste disposal and the environmental problem of waste disposal.

Chapter three focuses on methods of waste disposal including the characteristics and nature of incineration, the activities involved in the combustion process of hospital waste and the nature of incinerator stack emissions. The biological material released to the environment are described. Other methods of disposal are discussed.

Chapter four discusses the perceived and inherent risks associated with hospital waste incinerations. It defines risk and attempts an assessment of the levels of acceptability of risks. It also examines existing theories of risk and does an in depth review of risk evaluation methods. Such methods as exposed preferences, risk- cost benefit analysis, natural standards and expressed preferences are discussed and assessed. The chapter continues with ways of determining accident and chemical risks and concludes with a discussion of the problems encountered in risk analysis.

Chapter five discusses Environmental Impact Assessment, EIA including the methods used to produce an EIA. The advantages, disadvantages and its use in the UK and Iran are reviewed. This chapter also discusses Environmental Health Impact Assessment (EHIA).

Chapter six is concerned with a critique of an Environmental Impact Assessment submitted by Environmental Technology Consultants Ltd. (ETC).

Chapters seven and eight discuss the perception of residents about hospital incinerators and includes two separate case studies from the UK (Kirkby) and Iran (Ahwaz). The results of the data collected during this research are presented in these chapters and are analyzed and discussed.

Chapter nine discusses the effect of hospital waste incineration on human health. The factors influencing human exposure are identified and evaluated. The factors which cause the most harm to human health, such as products of incomplete combustion, halogens, the oxides of nitrogen and sulphur, particulate and trace metals and their complexes are discussed. The health effects of chemical substances, such as liver injury, cancer and respiratory disorders, are reviewed in the later sections of this chapter. The chapter concludes with a review of the psychological and social impacts of hospital waste incineration in a given locality.

Chapter ten is concerned with a critique of some EIA methods. This chapter also analyses the application of the Leopold's Matrix in the installation of hospital waste incinerations.

Chapter eleven is presented as a conclusion and makes a number of recommendations.

1.4 General Literature Survey

Although there have been many studies of incinerators in general, few studies have been published of hospital incinerators in particular. One example of a hospital incinerator study was carried out by the Incinerator Institute of America in 1968. The disposal of infectious solid waste and human body tissue waste became a problem to a hospital in Los Angles, USA. The air pollution control district began to ban the use of on-site hospital incinerators. The design of the hospital incinerators had been inadequate to completely combust the waste being incinerated. Clouds of dark smoke linked with odours from incomplete combustion resulted in plentiful complaints from hospital neighbours (Kremer, et al., 1975).

The United States Army installed a new hospital waste incinerator at the Walson Army community hospital in New Jersey, during 1980 to dispose of medical and related waste. Murnyak and Guzewich reported as follow :

" Chloride/Chlorine emissions from a hospital's medical waste incinerator were quantified in conjunction with a particulate emission stack test. Chlorine emissions averaged 100.5 mg/m^3 with a standard deviation of 72 mg/m^3 for five sample runs. It was estimated that the plastic content of the waste burned varied up to about 30%. Since, in general, emission standards for chlorine from medical waste incinerators do not exist, a simple diffusion model technique is suggested to estimate a safe distance to locate a medical waste incinerator from occupied buildings." (Murnyak and Guzenich, 1982).

The available literature on the matter of bacterial emissions from hospital incinerators comes from five studies (see chapter 3). Waste spiked with Bacillus subtilis was incinerated in a hospital incinerator. Although bacteria was found in the hospital incinerator stack gas, no Bacillus subtilis were recovered from the stack gas. This result suggests that the source of the stack gas bacteria was not from the unburned waste or from out-door air. Analysis of samples of air from the incinerator room shows that the source of stack gas bacteria was most likely the combustion air (Allen, et al.,1989).

Recent studies in the United States of America and Europe shows that adipose tissue and human breast milk are contaminated with polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), (Schecter, et al.,1985; Ryan et al., 1985; Nygren, et al.,1987). Connett and Webster discuss a model for estimating the concentration of 2,3,7,8- tetra chlorodibenzo-p-dioxin (TCDD) in milk from a cow grazing near an incinerator. Their estimates show that one litre of milk is equal to breathing the air at the same point as the grazing cow for about eight months. They reported, the daily dose could be even higher for high-fat dairy products produced from this milk. For instance, ingestion of about one hundred and fourteen grams (one quarter pound) of butter would be equivalent to about 1.5 years of inhalation (Connett and Webster, 1987).

Lloyd, et al. (1988) reported about twinning in human populations and in cattle exposed to air pollution from incinerators.

"The incineration of chemical and other waste may release polychlorinated hydrocarbons, some of which have oestrogenic properties. Increased numbers of twins had been reported anecdotally in cattle at risk from plumes from two incinerators near the town of Bonnybridge in central Scotland and also in cattle near a chemical factory in Eire. It was decided to follow up these reports in central Scotland and also to test the hypothesis that the frequency of human twinning might be increased there. Data on human twin and single births in hospitals in central Scotland were obtained for the years 1975-83. The twinning rates in areas exposed to airborne pollution from incinerators were compared with the background rates present in neighbouring areas. Farmers provided information on calving among the herds of two farms close to the incinerators. The frequency of human twinning was increased, particularly after 1979, in the areas most at risk from air pollution from the incinerators. Among the dairy cattle, there was a dramatic increase in twinning at about the same time." (Lloyd, et al., 1988).

Lee, et al., provide an overview of hazardous / toxic waste incineration. This paper presents an incineration summary ranging from analysis of broad regulatory and permitting requirements through more detailed explanations of typical incineration processes and monitoring techniques. Incineration has been identified as a very efficient process to eliminate the hazardous waste produced by industry (Lee,C.C., et al., 1986).

Garner and Favero (1985) reported there is no epidemiologic documentation to indicate that most hospital waste is any more infective than domestic waste. Also , there is no epidemiologic documentation that hospital waste disposal practices have caused disease in the community. Therefore, recognising wastes for which special precautions are indicated is mostly a matter of judgment about the relative risk of disease transmission, particularly for pathological wastes (Garner and Favero, 1985).

Openshaw et al. (1987) reported that there may be a link between incineration and ill health in their work on childhood leukaemia in Newcastle. This study, as well as confirming the occurrence of a 'cluster' of cases near the Sellafield nuclear reprocessing plant, has shown the presence of a further cluster in Gateshead, a finding which has been linked tentatively to the presence there of a municipal incinerator.

According to Gatrell and Lovett (1992) incineration is not the only form of waste disposal that may increase health problems. Control tipping or landfill accounts for by far the greatest percentage of hazardous waste disposal, and if sites are poorly located in relation to underground hydrology, and the leachate leaks into surrounding aquifers, then people may suffer from groundwater contamination. They concluded that, if we are to make improvements in assessing potential links between incineration and human health we need access to better information. If there is actually a link with incineration and cancer of the larynx then such a link may take years to display itself. They believe that in the absence of additional information it is foolish to claim that living near an incinerator has 'caused'cancer of the larynx. It may be more beneficial to look for potential links to respiratory diseases and to monitor attendances at general practitioner surgeries. They have also highlighted the need for better information on congenital malformations if there is to be any improvement in studying possible environmental factors in the aetiology of eye defects (Gatrell and

Lovett, 1992).

Much risk assessment work for hazardous waste incineration has been done. Oppelt (1987) reported that most attention has been focused on the risk associated with air pollution emissions. This is because they appear to represent the most important source of off-site human exposure and there is no opportunity for secondary containment or treatment of emissions once they leave the stack. The typical result of these explanations indicates that the individual cancer risk because of hazardous waste incineration over seventy years of life is of the order of one in 100,000,000,000 (10^{-11}) to 100,000 (10^{-5}) (Oppelt, 1987).

Sloane and Sherbine (1988) have reported a preliminary analysis of municipal waste incinerator reliability based on incomplete design data and no control information (Sloane and Sherbine, 1988).

Publications and reports show that the utilization of EIA techniques in hospital waste incinerators is very poor. The calculations of potential impacts have used many assumptions which could be significantly improved by empirical data (see chapter five). But there are many publications about different aspects of environmental impact and incinerators for example, Wilson and Miller, 1978; Hjelmar, 1982; Kent and Prickett, 1985; Cundari and

Lauria, 1986; Woodfield, 1987; Repa and Kiser, 1988; Kellermeyer and Ziemer, 1989.

The environmental impacts correlated with hospital waste incinerator ash management can be classified into two extensive categories, short-term (fugitive emission) release and long-term (leachate) release. Short-term release refers to the impacts correlated with ash handling and transport. The Environmental Protection Agency (EPA) has issued draft guidance regarding proper handling, transport and design of disposal units (EPA, 1988a). Short-term impacts are primarily air emissions and do not appear to illustrate significant pathways of exposure and environmental impacts when basic mitigation measures are used at the incineration facility and ash disposal site. The methods for verifying this in short-term contaminant releases, are not well established (Kellermeyer, et al., 1987). Long-term contaminant release to the environment produces surface water, groundwater and soil contamination as a result of leachate production (Woodfield, 1987).

During the 1980's the U.K. public was made acutely aware of the hazardous waste and disposal pathways issue by continuous media coverage of the environment. The complications of the issue were brought to the public's attention by radio, television, newspaper, magazine and pamphlet coverage of the hazards of municipal and hospital incinerators. For example, recently, there have been many articles in the local Press reporting on a proposed plan to build a hospital incinerator in the Kirkby area of Merseyside (See Appendix 2.).

In spite of the many technological advances in solid waste incineration, increasing opposition is common among many officials and some vocal portions of the residents tending to prevent the use of incineration as a waste management strategy. This opposition is the outcome of many forces, containing memories and knowledge of earlier incineration technologies that have now been abandoned, and growing information concerning potential problems that could be caused by extreme emission from hospital incinerators, and general public scepticism concerning incineration as a solution to hospital waste disposal problems.

A waste management plan for the disposal of hazardous waste or hospital waste should contain all aspects of an Environmental Impact Assessment (EIA). Cross et al. (1990) discuss the hazards relating to the disposal of various types of waste. The UK Department of Health and Human Services (1978) discussed the isolation techniques suitable for use in hospitals. Among the literature on the different treatment techniques, the principles of sterilization and waste sterilization are described by Rubbo and Gardner, (1965); Perkins, (1969); and Block & Netherton, (1977). The EPA (1988 b), reported on the results of a study of air emissions from hospital waste incineration. The WHO (1985 c). reviewed recent developments in the handling, transport, treatment and disposal of waste for hospitals. Johns Hopkins Hospital (1979) reported on the policies and procedures for the control of infections in hospital waste. McCrae (1980) described waste generation rates, waste characteristics, visible emissions from the Royal Jubilee Hospital in Victoria, B.C., and discussed reduction ratios, system gross and net costs, and heat recovery for hospital waste incineration.

In the United Kingdom, a study was commissioned by the Department of the Environment (1989) to monitor the level of polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs) and Polychlorinated dibenzo-p-dioxins (PCDDs) in the environment. This report confirmed that these substances are ubiquitous in the environment. Signs were also found in milk, human and animal fats, and other biological tissues. The importance of these findings for human health will be discussed in chapter six.

The problems arising from hazardous and hospital waste disposal have been widely reported in the UK by Hnatko (1975), Lund (1977), and a report made jointly for the Oxford Area Health Authority and the Waste Disposal Department of Oxfordshire County Council by the Environmental Safety Group, Harwell. This report was commissioned because of operating difficulties at the incinerator. These difficulties were from lack of capacity producing excessive fumes and smoke. The Oxford Waste Disposal Authority commissioned a report on the respective costs of incineration and disposal by landfill for hospital waste.

The Department of the Environment, through its directorate of Air, Noise and Waste has the responsibility of ensuring that waste generated in Great Britain is disposed of in an environmentally acceptable manner. The Department of the Environment (1983) commissioned work to study clinical waste disposal problems. This study concentrated principally on the segregation, handling and transport of clinical wastes within the hospital environment. The report also concentrated on the final disposal of such wastes and studied the different available options. The first part of the paper is a code of practice for the disposal of clinical waste, and in part two it gives more advice on such matters as the evaluation of clinical waste, its sources, segregation, collection, transport and disposal. It suggested that all clinical wastes which are non-infectious and non-hazardous may be disposed of by landfill. Incineration is recommended as the only disposal route for haematological and laboratory wastes, human tissue and infected wastes.

The Health Services Advisory Committee (1982) on the request of the Health and Safety Commission Executive published a paper entitled "The Safe Disposal of Clinical Waste ". Tickell and Watson (1992) stated, "dirty old incinerators are the dumping grounds for most clinical waste. Tougher laws are putting pressure on Britain's hospital managers to clean up their act."

Woodfield (1987) produced a paper at the request of the Department of the Environment. This study covers an extensive range of pollutants but pays special attention to heavy metal and dioxin emissions. It reviews large municipal solid waste incineration plants in the UK, and compares them with those in other developed countries. The study does not consider the incineration of hospital waste, but some mention is made of the environmental impact of incineration.

Problems arising from waste and hospital waste are not peculiar to the UK but have been reported in the USA by National Analysts (1973) and Sigler's (1973) WHO research on solid waste pollution. National Analysts (1973) studied the level of knowledge of solid waste practices in respondents' communities. This study found little awareness of disposal practices among their housewife respondents, who did not know the cost of disposal. When they had a little knowledge of local recycling activities, they were highly aware of solid waste as a problem. Sigler studied the awareness of solid waste as a problem; attitudes toward solutions to solid waste and other environmental problems, and the consequence of social variables in explaining the differences in attitudes. He found a contrary relationship between age and perceived seriousness of the attitudes toward pollution, for example, younger people felt the problems were more serious than did older persons. He found a positive relationship between educational level and perceived seriousness, for instance, more highly educated people rated pollution as more serious and there was the same positive relation for income but there was no relationship between sex and perceived seriousness.

Stern et al. (1989) studied potential exposure levels and health effects of neighbourhood exposure to a municipal incinerator bottom ash landfill. This research was conducted to examine the potential for adverse health effects resulting from neighbourhood exposure to dust and soil from a municipal incinerator bottom ash landfill site, which received ash from a single nearby incinerator from 1954-1973. The incinerator providing the ash operated during this entire period without pollution control devices, and thus supplied only bottom ash to the landfill. The soil was analyzed for ten heavy metals, polychlorinated dibenzodioxins, polychlorinated dibenzofurans, 2,3,7,8-tetrachlorodioxin and furan congeners, polycyclic aromatic hydrocarbons, and polychlorinated biphenyls. Soil concentration for these materials were converted to estimates of exposure, health effects and or cancer risk by the application of a general exposure model (and exposure or effect and exposure or risk models for special materials). The outcomes of modelling and soil analysis show that the level of lead discovered on the site was considerably above the recommended levels of the Centres for Disease control (in USA) and may lead to an increased blood lead level in exposed children. The materials measured in the soil on this site were considered to .he small, and to have no significantly elevated cancer risk. Comparison of levels of different materials obtained at this site with levels obtained in fresh bottom ash in other studies suggest that these outcomes may be applicable to exposures from other municipal incinerator bottom ash landfills.

Howe et al. (1988) reported on a comparison of actual and perceived residential proximity to toxic waste sites. This research compares perceived residential distance and actual distance to toxic waste sites. The data was abstracted from a survey of 7,533 male and female residents of New York State, including New York, and aged 25-74, and who had a driver's license. The survey used respondents (N = 317) from one county known to have a large number of toxic waste sites. "Using linear regression, the variance explained in concern scores was 22 times higher with perceived distance than for actual distance. Perceived residential distance was a significant predictor of concern scores, while actual distance was not. Perceived distance explained less than 5$\%$ of the variance in concern scores."

Baker et al. (1988) reported one of the largest community-based health studies concerning health effects associated with living near a toxic waste disposal site. It was a health study of 2,039 persons in 606 households, in two communities near the String-Fellow hazardous waste disposal site, Riverside County, California. A community near the site and one further away were studied to examine whether rates of adverse health results were increased among persons living near the site. The 125 page interviewer-administered household questionnaire, medical records of cancer cases and pregnancies, birth and death certificates produced an extensive health record for each subject. The study areas appeared similar with respect to cancer incidence, mortality and pregnancy outcomes. In contrast, rate ratios were larger than 1.5 for 5 of 19 reported diseases, for example, asthma, bronchitis, angina pectoris, skin rash, and ear infection. Prevalence of odds ratios for 23 symptoms were uniformly larger than 1.0 and 8 symptoms had odds ratios larger than 1.5. These were pain in ears, blurred vision, frequent urination, frequent diarrhoea, unsteadiness when walking, daily coughing for more than a month, and nausea. Baker et al., believed "These results indicate that future community-based health studies should include medical and psychosocial assessment instruments sufficient to distinguish between changes in health status and effects of resident reporting tendency".

The management of infectious waste from hospitals was also reported :- Iglar, 1973; Rutala et al., 1983; Brenniman . et al., 1984; Cross & Noble, 1973; Marrack,1988; Hall, 1989; Hershkowitz, 1990; Cheremisinoff, 1989; Garvin, 1988; Cross . et al., 1990 ; EPA, 1988b; Airan . et al., 1980.

Hospital waste disposal by incineration was reported by :-
Brunner and Brown, 1988; Brunner et al., 1984; Brunner, 1987. Air pollution emission from the incineration of hospital waste:- Kelly et al., 1983; Allen et al., 1986; Powell, 1987; Murnyak & Guzewich, 1982; Allen et al., 1989; Smith, 1987; Doyle et al.,1985; Lauber, 1987.

In Canada, the management of hospital waste was reported by Campbell . . 1989; Canadian Standards Association, 1988, Environment Ontario, 1986.

In Germany, disposal of pathological and infectious wastes from hospitals was investigated by Reichelt, 1977; Reise, 1990.

In 1985 the World Health Organization, Regional Office for Europe published: The Management of Waste from Hospitals, Euro Reports and Studies No. 97. This waste management paper concentrates mainly on waste categories and their sources, occupational hazards and health risks, the impact of health care waste on human health and the environment, waste handling, storage, transport, treatment and disposal methods. The literature indicates that the local inhabitants near incinerators may suffer health problems (WHO, 1985c).

1.5 Methods

This thesis makes a study of two communities. A major one, Kirkby, UK and the other a minor one, Ahwaz, Iran. The minor case concerns only the results of a questionnaire. The major study also includes information about health and a critique of an EIA submitted by Environmental Technology Consultants Ltd. (ETC).

In this thesis it was not possible to make a fair and well balanced comparison of the two communities because they were far apart in terms of :- culture, social behaviour, economy, climate, political and geographical characteristics and their reaction to the experience of having a hospital waste incinerator proposed or installed close to their neighbourhood. The study has, however, tried to present the attitudes of these communities toward a hospital incinerator and to use this information for the assessment of the environmental impacts at Kirkby and to establish a Leopold environmental impact matrix.

This thesis has therefore been prepared by the collection, review and analysis of information collected by :-

1. A review of relevant literature.

2. Questionnaire :-

It was intended that the questionnaire would provide information on the perception of populations of Kirkby and Ahwaz of incinerators in general and particularly hospital incinerators. It was hoped that their perceived needs could be established, and the adequacy of existing provisions to meet such needs, assessed. Information was therefore collected in the following areas:-

a. Demographic characteristics, life-cycle stage, and social environment,
b. Personality factors including perceptions, motivations and attitudes,
c. Awareness of existing incinerators,
d. A comparison between risk perception from hospital incinerators and risk perception of smoke, industrial air pollution, traffic air pollution and crime (See Chapter 7 and 8).

3. Personal observations were also made in the hospital incinerators in the UK and Iran.

4. The critique review of the EIA report submitted by ETC. for the proposed Kirkby incinerator.

CHAPTER TWO

WASTE

2.1 Introduction

This chapter investigates waste management in general and particularly medical waste from hospital and other health care facilities. Over the last 20 years there has been a large change in waste disposal. It would seem reasonable for this study first to attempt to describe in which way the quantities and composition of waste have changed and to explain the previous and present position. In this chapter, therefore, first waste in general is considered because the majority of hospital waste is of domestic origin. Hospital wastes are divided into the general categories of ordinary household waste, hazardous waste, infectious waste, chemical waste and radioactive waste. The classification and quantities of wastes are discussed and finally waste legislation is described. Hazardous and infectious waste is described in detail, chemical and radioactive waste in brief but mining and agricultural waste, as they are not relevant to the study, are not described.

2.2 General discussion

Every year, thousands of tons of solid waste are generated as the product of the ordinary manufacturing, distribution, purchasing, use and disposal activities of big cities. These wastes include paper, wood, rubber, plastic, clothing, leather, metals and solutions

(Halliwell, 1972; Skitt, 1972; Baum et al., 1973; Diamant, 1974; Bridgwater and Lidgren, 1981; Harthill, 1984; William and Robinson, 1986; Forester and skinner, 1987; British Medical Association, 1991).

For the effective management, disposal and control of waste it must be clearly defined, but legal definitions are different from country to country even within the EEC. Waste can, however, be defined as unwanted material arising in the course of production and consumption. The UK Government's Environmental Protection Act 1990 goes further defining waste as follows:-

1. Any substance which constitutes a scrap material, an effluent or unwanted surplus substance arising from the application of any process.
2. Any substance or articles which demand to be disposed of as being contaminated, broken, worn out or otherwise spoiled. (Explosives are not included.)

The EEC defined waste as:
Any substance or object the holder disposes of or is demanded to dispose of pursuant to the provisions of the national law in force (Commission of the European Communities, 1992). Everywhere in the world waste is often discussed according to the following criteria:-

a - The source of the waste eg: domestic, commercial, industrial, agricultural and hospital.

b - The method of disposal eg: landfill, incineration, tipping, composting, pulverisation.

c - The degree of risk for human health and environment eg: toxic waste, infectious waste.

d - Economic, for example, in relation to the production of a solid refuse-derived fuel (RDF.)

According to Hay (1984) "A waste is any substance for which the owner or generator has no further use and which he discards." Waste may be solid, semi-solid, liquid, gaseous and in each case may be toxic or non-toxic, combustible or non-combustible. For the aims of management, waste can be placed within two classifications: controlled and uncontrolled as laid down by the Control of Pollution Act 1974. In the UK from one day to the next regulation of the disposal of controlled waste is the responsibility of the local waste disposal authorities. With the exception of domestic and commercial refuse, waste disposal is usually carried out by private contractors. Most wastes are controlled, but agricultural waste, quarry wastes and wastes disposed of on the site where they have arisen and colliery spoil, are uncontrolled.

2.2.1. What is solid waste?

Solid waste is generated daily by households, hospitals, commercial establishments, industries, governmental operations, and virtually every element of society. Solid waste is generally taken to include all non-gaseous, non-liquid waste generated from a large range of community activities, i.e., simply trash, rubbish or garbage. A significant quantity of this solid waste is hazardous. Municipal solid waste composition changes with time and by region. For instance in 1939 it was mostly garbage mixed with paper products, cans, dust, bottles, and cinders. From about 1955, solid waste grew less dense as less ash was produced. Since 1977, greater quantities of paper, glass and plastics have been produced imparting a higher calorific value to solid waste. In the USA. solid waste includes:-

refuse, garbage, slurries and all materials that are normally discarded after use and also by-products of manufacturing or mining activities that are normally discarded (Anon, 1979). In the UK solid waste includes:-

Municipal solid waste whose average composition is, metals (mainly ferrous) 9%, glass 9%, paper 32%, plastics 8%, vegetable 20%, dust and others 18%, textiles and others 4% (Porteous, 1992).

2.3. Hazardous waste

Hazardous wastes are produced in many different ways in nearly all countries. Generally they are chemical or allied products. Industry accounts for 50% to 70% of all hazardous waste produced. Current estimates for the United

States of America indicate that some 60% of all hazardous waste is produced by chemical and allied industries (Maltezou et al., 1987). A number of countries have defined "hazardous waste" in their respective national regulations. The examination of a compilation of these definitions indicates that no two are similar. However the term "hazardous waste" means a waste which, because of its quantity, concentration or physical, chemical or infectious characteristics, poses a substantial present or potential hazard to human health or the environment or may cause or significantly contribute to increases in either mortalities or an increase in serious irreversible (or incapacitating reversible) illnesses. They may contain or result in:-

a - Chemicals which are toxic.
b - Fire and explosion.
c - Oxygen insufficiency.
d - Ionizing radiation.
e - Biological hazards.
f - Physical safety hazards
g - Electrical hazards.
h - Noise pollution.

a - Chemicals which are toxic

Most waste disposal sites involve a variety of chemical materials which are toxic. These materials can enter the exposed body by inhalation, ingestion or direct skin contact. A contaminant can cause damage at the point of contact or can act systemically by providing a toxic effect at other points in the body. Some chemicals may cause apparent symptoms such as vomiting, coughing, rashes or eye watering. Other chemicals may cause health harm without any such warning signs. Health effects such as respiratory disease or cancer may not become apparent for many years after exposure (see chapter 6).

b - Fire and explosion

Papers and lists have been published to show the relative magnitudes of the four categories of damage associated with fire, explosion, toxic release and nuclear accident. These suggest that, in so far as fatalities are concerned, fire is by far the most important (Withers, 1988). Fires and explosions may happen spontaneously or by other means including mismanagement of the stored materials. There are several potential causes of fires and explosion at hazardous waste sites. For example, chemical reactions that generate fire and explosion, the ignition of flammable or explosive chemicals or the irritation of shock or friction-sensitive compounds. At hazardous waste disposal sites, fires and explosions not only pose the obvious hazards of great heat, open flames, smoke inhalation, flying objects, but may also cause the release of toxic chemicals into the environment (Martin, et al, 1987).

c - Oxygen insufficiency

Oxygen insufficiency may result from its displacement by another gas, or the consumption of oxygen by a chemical reaction. Oxygen insufficiency can cause vomiting, heart and brain damage, unconsciousness and death.

d - Ionizing radiation

Ionizing radiation is produced by equipment such as X-ray apparatus or spontaneously emitted by the radioactive materials which are widely and increasingly used in industry. Radioactive substances are used in the production of electricity and in industry, medicine, research and defence. Their use results in gaseous, liquid and solid wastes which can be classified into three categories : high level (or heat generating) waste such as vitrified radioactive waste, first cycle reprocessing waste and spent fuel; intermediate level waste such as ion exchange substances, sludge from fuel storage ponds, concentrates from liquid waste treatment, fuel cladding and plutonium contaminated materials; and low level waste such as paper, clothing, laboratory equipment and soils (National Society for Clean Air and Environmental Protection, 1991). These radioactive materials radiate one or more of three kinds of harmful radiation: alpha, beta and gamma. Alpha radiation poses little threat outside the body, but can be hazardous if substances that radiate alpha radiation are ingested or inhaled. Beta radiation can cause damaging "Beta Burns" to skin and harm the subsurface blood system. Gamma radiation can cause serious and permanent damage to the body (Martin et al., 1987).

e - Biological hazards

Biological health hazards originate from living things or are living things themselves which are capable of harming, or causing harm in humans. They include animals, insects, various kinds of micro-organisms such as bacteria, viruses and fungi and poisonous plants. Hospital wastes and research facilities may contain disease-causing bacteria and viruses which could infect waste disposal site personnel. Similarly, chemical hazards and etiologic agents may be dispersed in the environment via wind and water.

f - Physical safety hazards

The degree of the reaction of a waste disposal site to any material depends upon the physical conditions. Hazardous waste sites may contain many physical hazards such as sharp objects like nails, metal shards and broken glass; holes or ditches, slippery surfaces and steep grades and uneven terrain. Some physical hazards are a function of the work itself. Injuries and accidents at work are more often associated with general manufacturing, mining and building industries and less frequently with hospital waste disposal employment.

g - Electrical hazard

Electrical hazards may occur through bad design, construction and installation, from incorrect operation and misuse or inadequate standards of protection and maintenance. Electric shock is caused by an electric current flowing through the body, affecting the nervous system and upsetting bodily organs and function. The heart is specifically susceptible to a condition known as ventricular fibrillation at currents of as little as 50 milliamps (0.05 Amp) flowing for a few seconds (Miosh, 1991).

h - Noise pollution

Noise is an important concern for advisers in safety and hygiene. Living or working around large equipment often results in excessive noise. Excessive exposure to noise causes physiological effects including physical injury, pain, temporary and sometimes permanent hearing loss and reduced muscular control. It also interferes with communication and increases potential hazards due to the inability to warn of danger or to properly instruct in safety precautions.

The Hazardous Waste Inspectorate (HWI) estimates that there are 1682 sites licensed for disposal of hazardous waste in England and Wales (HWI., 1985). There are two principal ways in which hospital wastes present hazards;

through toxicity and infectivity.

According to one study, hospitals produce 0.056 lb/bed or 0.025 Kg/bed per day of hazardous waste. Which for a 200-bed hospital results in 152 Kg or 336 lb of hazardous waste per month (Cross & Robinson, 1989). Cross and Robinson (1989) listed the 45 chemicals or groups of chemicals that were reported as possibly being generated by hospitals. The source and types of hazardous waste that may be generated in hospitals are illustrated in Figure 2.3.1.

Many Scientists called upon to assess the potential environmental impact and/or health effects of a hospital disposal site find that the substances which have been disposed of at the site have not been adequately documented as regards the identities of the specific chemicals, or the sources, quantities, and dates of disposal. Thus, it is necessary to determine the chemicals which are present at the disposal site and to identity those chemicals which are escaping from the site and their route of entry into the environment.

Figure 2.3.1 Examples of potential sources and types of hazardous wastes/generated by hospitals.

Source of Hazardous Waste :	
Anaesthesia	Nuclear Medicine
Blood bank	Nursing
Central supply services	Obstetric/gynaecology
Dentistry/oral surgery	Oncology/radiation
Dialysis	Oncology
Emergency	Pathology/histology
Environmental sacs./ Housekeeping/Laundry	Pharmacy
	Engineering
Food service	Print shop
Intensive care	Radiology
Clinical laboratories	Respiratory care
Materials management	Security
Morgue	Surgery
Examples of Potentially Hazardous Wastes:	
Acids/Caustics	Germicides
Adhesives	Heavy-metal solutions
Alcohols	Infectious waste
Ammonia	Inks/printing materials
Anaesthetic gases	Insecticides
Antineoplastic drugs	Iodine
Asbestos	Mercury
Bromine	Mutagens
Carcinogens	Nitrous oxide
Chlorine	PCBs
Chromates	Pesticides
Clinical test reagents	Pharmaceutical agents
Cleaning products	Phenols
Quaternary ammonium compounds	Compressed gases
Corrosives	Radioisotopes
Photographic chemicals	Rodenticide
Solvents:organic,nonchlorinated	Disinfectants
Solvents:organic, chlorinated	Dyes
Ethylene oxide	Teratogens
Explosive gases and liquids	Toluene
Flammable gases and liquids	Formaldehyde/Formalin
Water- treatment chemicals	Xylene
Fungicides	RCRA-listed wastes

Source: Cross and Robinson, 1989.

2.4. Infectious waste

The definition of infectious waste has been debated for many years. The Centres for Disease Control (USA) findings strongly influence how infectious waste is defined, how it is managed in or out of hospitals and to a certain extent, how it is disposed of. Dorland's Illustrated Medical Dictionary (1974) defined infectious as being "capable of producing infection; pertaining to or characterized by the presence of pathogens" (Dorland's, 1974). The terms clinical waste, infectious waste, medical waste, and hospital waste are used interchangeably. In this study the term "hospital waste" refers to all kinds of waste produced by all types of health care services.

Pathogenic micro-organisms include viruses, bacteria, fungi, protozoa, viroids and rickettsiae. But not all pathogens are micro-organisms. The pathogens of relevance to this research are those whose presence in different waste gives the waste a potential for causing disease. Infectious waste can be divided into 13 categories which are as follow :-

a. Pathological wastes
b. Isolation wastes
c. Cultures and stocks of etiologic agents
d. Blood and blood products
e. Other waste from autopsy and surgery
f. Discarded biologicals
g. Contaminated laboratory wastes

h. Dialysis unit wastes

i. Contaminated equipment

j. Sharps

k. Contaminated food and other products

l. Animal carcas es and body parts

m. Animal bedding and other wastes from animal rooms.

2.5. Quantities of waste

According to the Office of Technology Assessment, around 250 million metric tons of hazardous waste are generated each year. From this quantity around twenty percent (50 million metric tons) contain organic material and can be incinerated. This incinerable quantity does not include contaminated soils, nonmetallic sludges, and certain aqueous waste, some of which contain organic compounds and could be considered candidates for incineration under special circumstances (Lewise, 1961; Graydon 1979; American Society of Mechanical Engineers, 1988).

In the EEC, according to Dr Bennett, Directorate General for Environment, Nuclear Safety and Civil Protection, the member states of the European Community together produce a total of approximately 2,000 million tons including:-

- 400 million tons of waste from the extractive industries and power stations,
- 230 million tons of sewage sludge,

- 90 million tons of household waste,
- 2 million tons of waste oil,
- 180 million tons of construction and demolition debris,

In the majority of the member states, 60% of household waste is dumped, 33% is incinerated and some industrial waste is reused (Bennett, 1989).

By 1989 England and Wales produced approximately 2,505 million tons per annum of (liquid, solid) domestic, trade and medical waste (Environmental Committee on Toxic Waste, 1989). The kind of waste produced is illustrated in Table 2.5.1.

TABLE 2.5.1 Total waste in England and Wales.

Type	Quantity (million tons p.a.)
Liquid & industrial effluent	2000
Agricultural	250
Mines & quarries	130
Industrial	50
Hazardous & Special	3.9
Special	1.5
Domestic & Trade	28
Sewage & Sludge	24
Power Station ash	14
Blast Furnace Slag	6
Building	3
Medical waste	0.15
Total	2505.15

Source: Environmental Committee on Toxic Waste, Second Report 1989.

According to the same report, hazardous waste is disposed of in several different ways as given in Table 2.5.2.

TABLE 2.5.2

Disposal routes for hazardous waste

Method of disposal	Quantity (tons p.a.)	Percent
Landfill	3,273,000	83
Land based incineration	62,400	1.6
Chemical treatment	308,100	7.9
At Sea:		
Dumping	289,500	7.4
Incineration	3,754	-

Source: Environmental Committee on Toxic Waste, Second Report 1989

There is an indication that these quantities will continue to increase. In 1990 in the UK approximately 10% of industrial waste was incinerated (NSCA, 1990). Ten percent of trade, domestic and industrial waste was also incinerated annually by the forty municipal waste incinerators in the United Kingdom (Woodfield, 1987).

For a long time the disposal of the wastes produced by Society has been a case of 'out of sight, out of mind'. Gradually, this attitude has begun to change and it is increasingly recognized that the goal of a cleaner Society can only be achieved by diminution and control of all kinds of pollution and of all types of waste.

2.5.1 Quantities of hospital solid waste

Hospitals are invariably associated with the generation of large quantities of infectious and organic waste very rich in pathogens. The handling, transport and disposal of such wastes is expensive and also has inherent risks to human health. Former West Germany and Switzerland give good models for an improved system of hospital waste disposal. These countries, along with Sweden, have nationally consistent medical waste procedures and have recorded little mismanagement of hospital waste in the past ten years (Hershkowitz, 1990).

In the USA hazardous waste constituted about 7% of the total or 260 million tons of waste produced per year. There are over 750,000 generators of hazardous waste, 10,000 transporters and 30,000 treatment, storage and disposal facilities (Hammer, 1980). The EPA estimated that in 1981, about 4 billion tons of solid waste were produced in the USA. This total includes both "ordinary" municipal solid waste, (newspapers, product packages, food, cans and bottles generated at the rate of 1.135 Kg per person per day) and the waste generated by US industries. The EPA estimated that 10 - 15 percent of the industrial waste is hazardous.

Hospitals produce solid waste in quantities out of proportion to their size. According to Cross (1973) in the USA, compared to an estimated national total of 3,650 million tons of solid waste produced annually by the whole population, hospitals produce an estimated 55 million tons of solid waste annually or 1.5 percent of the total. In terms of infectious properties (The categories of which are summarised in Table 2.5.3) medical waste has increased greatly during the past three decades. Hershkowitz (1990) believes that "Nobody knows how much medical waste is produced in the USA, but estimates that for the nation's hospitals there were between 500,000 and 3 million tons a year. Although the amount is minuscule compared with all United States waste, in 1988 the equivalent of just two bags of medical waste was enough to contaminated and close several beaches in the Northeast and cause approximately $1 billion to $1.5 billion in losses for local businesses.

According to Tickell and Watson (1992) in Britain, between 200,000 and 400,000 tonnes of hospital waste are collected each year in the yellow plastic bags.

TABLE 2.5.3

Generation rate of hospital waste

Waste	Weight %	Generation rate based on 9 Kg/ bed/day
Pathological	0.5	0.045
Infectious	10.0	0.900
General/administrative (non - infection)	50.0	4.500
Food	30.0	2.700
Cardboard	9.5	0.850
Total	100.0	9.000

Source: Cross, 1985

According to a survey on waste from hospitals and other public health locations in the member states of the European Community, for a current population of 258.8 million, the nine European countries have 2,644,100 hospital and other health service establishments. If we assume an occupancy of approximately 80% as a European hospitals average, 2,115,280 beds are occupied daily. If the waste per occupied bed per day is put at an average of 1.5 Kg we get 1.16 million tonnes of waste per year in hospitals of the member states. Hospitals in the UK in 1980 produced some 155,000 tons, of which approximately 33,000 tons were clinical wastes. A comparable estimate is not available for clinical waste arising from community health services, but it could be as much as 15 percent of clinical waste arising at hospitals (Commission of the European Communities, 1982 and Department of the Environment, 1983). An estimate of the quantity of hospital waste arising from NHS hospitals in Mersyside UK gave a figure of more than 8,000 tons per annum (Environmental Technology Consultant Limited, 1989).

2.6 Classification of wastes

There is a difficulty in defining waste as toxic or hazardous because this terminology includes any substance that could be harmful both to humans and to the environment. In the UK there are no legal categories for waste definition even though hazardous waste is legislated for under an European Economic Community directive . The EEC definitions which exist for the terms 'toxic' and 'hazardous' . have a wider meaning in the UK and may include difficult, special, clinical, toxic or controlled waste which is shown in Figure 2.6.1.

Figure 2.6.1 Categories of hazardous waste in current use

Controlled wastes: These are the wastes subject to the Control of Pollution Act (COPA) 1974. Controlled wastes are divided into three categories: household, commercial, and industrial. These wastes do not include explosives, waste from mines and quarries, or agricultural wastes.

Special waste:
This is a category of waste which 'is or may be so dangerous or difficult to dispose of that special provision is required for its disposal'. These wastes are given very specific definitions: either medicinal products available only on prescription, or specified materials which are dangerous to human health, or those substances with a flash point of 21°C or less. The House of Commons Environment Committee have recommended that the definition of special wastes be expanded to include clinical waste and also those waste which may damage the environment.

Toxic waste:
This is a rather loose definition, which is often used to refer to those wastes which have toxic properties but are not exactly equivalent to special wastes.

Hazardous wastes:
These are wastes which fall under the UK Transfrontier Shipment of Hazardous Waste Regulations 1988. As with toxic wastes, this definition is somewhat hazy under UK law, being analogous to special wastes. The new definition of hazardous wastes under EC Directive COM(88) 399 is more specific, including those wastes which are hazardous by means of their physical or chemical characteristics, the process by which they were produced, or their effect on human health or the environment.

Difficult wastes:
These wastes as defined by the Department of Environment (DoE) cover all special waste plus some other substances such as ferrous metal scrap which are not special wastes. However, this term is 'generally used to include wastes which could in certain circumstances be harmful in either the short or long term to the environment. It also includes wastes whose physical properties present handling problems'.(Department of the Environment, Waste Management Paper No. 4, 1988, para 3.4 (b)

Clinical wastes:
Clinical wastes include human tissue, body fluids, or excretions; drugs and medicinal products; swabs and dressing; urine containers, incontinence pads and stoma pads; syringes; and also needles, scalpel blades, and other 'sharps'. These have been defined by the Health and Safety Commission and by the DoE Waste Management Paper 25.

Source: The British Medical Association 1991.

In addition, following a meeting in January 1980 and considerable debate, it was decided that on the basis of several criteria waste should be included in the hazardous category, as shown in Figure 2.6.2. According to Hay (1984) hazardous wastes are defined as "Those wastes which, due to their nature and quantity are potentially hazardous to human health and the environment and which require special disposal techniques to eliminate or reduce the hazards".

Figure 2.6.2 Toxicity Criteria

TOXICITY is the potential for a waste to cause damage to the structure or disturb the function of an organism when exposed to that waste. Descriptive properties of TOXICITY include:

(A) LETHALITY - any waste which on exposure results in the occurrence of death.

(B) CARCINOGENICITY - any waste which on exposure results in a statistically significant increase in the occurrence or extent of malignancy

(C) TERATOGENICITY - any waste which on exposure results in a statistically significant increase in the occurrence or extent of physical or functional defects in the developing offspring.

(D) MUTAGENICITY - any waste which on exposure results in a statistically significant increase in the occurrence or extent of permanent alteration in the gene structure.

(E) PATHOGENICITY - any waste which on exposure results in a statistically significant increase in the occurrence or extent of any disease.

(F) INFERTILITY - any waste which on exposure results in a statistically significant increase in the occurrence or extent of reproductive failure.

Source: Hay 1984.

A report on waste establishments drawn up in 1968 by the Incinerator Institute of America classified wastes to be incinerated into seven categories (see Table 2.6.1). As a guide, the components of waste most usually encountered have been classified into various types along with their Kilo-Joule (KJ) values and their moisture content:

Type 0- Trash

This type of waste includes 10% dampness, 5% noncombustible solids and has a heating value of 9010 K.J. per kilo when burnt. This waste comprises compounds of high combustion value that burn easily. They include material such as cardboard, paper, cartons, wood boxes and combustible floor sweepings that are from trade and industrial activities. These components contain up to 10% (by weight) of laminated paper, coated paper, treated corrugated cardboard, plastic bags, oily rubbish rags and plastic or rubber scraps.

Type 1- Rubbish

This waste includes up to 25% dampness, 10% incombustible solids and has a heating value of 6890 K.J. per kilo as fired. This compound burns easily and consists of waste such as cardboard cartons, paper, wood scrap, foliage and refuse from industrial activities. The dampness is up to 20% by weight from restaurant or cafeteria waste but contains little or no treated, paper, plastic or rubber wastes.

TABLE 2.6.1 CLASSIFICATION OF WASTE TO BE INCINERATED

Classification of Wastes Type	Description	Principal Components	Approximate composition % by weight	Moisture Content %	Incombustible solids %	Value/Kg of Refuse as Fired	KJ of Aux. Fuel per Kg of waste to be included in Combustion Calculation	Recommended Min.KJ/hr Burn. Input per Kg waste
* 0	Trash	Highly combustible waste, paper, wood, cardboard cartons, including up to 10% treated papers, plastic or rubber scraps; commercial and industrial sources	Trash 100%	10%	5%	9010	0	0
* 1	Rubbish	Combustible waste, paper, carton, rags, wood scraps, combustible floor sweeping; domestic, commercial, and industrial sources	Rubbish 80% Garbage 20%	25%	10%	6890	0	0
* 2	Refuse	Rubbish and garbage; residential sources	Rubbish 50% Garbage 50%	50%	7%	4558	0	1590
* 3	Garbage	Animal and vegetable waste, restaurants, hotels, markets; institutional, commercial, and club sources	Garbage 65% Rubbish 35%	70%	5%	2650	1590	1364
* 4	Animal Solid and organic waste	Carcasses, organs, solid organic wastes; hospital, laboratory, abattoirs, animal pounds, and similar sources	100% Animal and Human Tissue	85%	5%	1060	3180	Primary 3636 Secondary 2272 1364
* 5	Gaseous, liquid or semi-liquid wastes	Industrial process wastes	Variable	Dependent on predominant components	Variable recording to wastes survey	Variable according to wastes survey	Variable according to waste survey	Variable according to waste survey
* 6	Semi-solid and solid waste	Combustibles requiring hearth, retort,or grate burning equipment	Variable	Dependent on predominant components	Variable recording to wastes survey	Variable according to wastes survey	Variable according to waste survey	Variable according to waste survey

* The above on moisture cement ash, and KJ as fired have been determined by analysis of many samples. They are recommended for use in computing heat release, burning rate, velocity, and other details of incinerator designs. Any design based on these calculation can accommodate minor variations. Source: Adapted, from IIA, 1968.

Type 2-Refuse

This type of waste is typical residential refuse and comprises up to 50% dampness, 7% noncombustible solids and has a heating value of 4558 K.J. per kilo upon combustion. This material has approximately equal amounts of garbage and rubbish.

Type 3-Garbage

This contains up to 70% moisture, up to 5% incombustible solids and has a heating value of 2650 K.J. per kilo. Garbage consists of vegetable and animal wastes from markets, cafeterias, hotels, restaurants, hospitals and other such institutions.

Type 4- Human and animal remains

Animal and other organic waste consists of up 85% dampness, 5% non-combustible solids with a heating value of 1060 K.J. per kilo as fired. Human and animal waste consists of organs, carcasses and solid organic wastes from hospitals, laboratories, abattoirs, animal compounds and similar sources.

Type 5- Liquid by-product waste

This kind of waste is gaseous, liquid or semi-liquid, e.g. tar or solvents, sludge, paints, fumes, etc. from industrial processes. K.J. values are very variable and must be determined in relation to the nature of the individual waste material.

Type 6- Solid by-product waste

This type of material is made up of items such as plastic, rubber, and wood from industrial processes. K.J. values must again be determined for individual compounds (I.I.A.1968).

2.7 Classification of hospital waste

Biomedical wastes are generated by hospitals, animal research facilities and laboratories all of which can be represented in hospitals. There are several criteria for classification of hospital waste. For example:

2.7.1. Classification of hospital waste by US EPA

The United State EPA has recommended that the following types of waste be considered infectious waste. There are six categories that meet these criteria:

1- Isolation waste.

2- Cultures and stocks of infectious agents and associated biologicals.

3- Human blood and blood products.

4- Pathological wastes.

5- Contaminated sharps (hypodermic needles, etc.)

6- Contaminated animal carcasses,body parts, and bedding.
Additional materials that might be considered as infectious include:

a- Dialysis-unit wastes.

b- Discarded biological material.

c- Contaminated food and other products.

d- Contaminated equipment.

e- Other wastes from surgery and autopsy.

f- Contaminated laboratory wastes (EPA, 1988b).

According to the Canadian Standards Association, (1988) biomedical waste can be classified into seven categories and seven sub-categories which are collected in different coloured bags. Table 2.7.1 shows the types of waste classified as being biomedical. The bag designations red, green, dark green, orange, yellow, blue and black are used in Canada. In the USA generally all of these wastes are classified as "red bags"; in the UK yellow bags are used.

Table 2.7.1
Summary of colour- coding/labelling requirements

Waste category	Waste sub-category	Colour- coding/labelling
Human/Animal* anatomical waste	Human anatomical	Red
	Infectious animal anatomical	Orange or Red
	Noninfectious animal anatomical	Blue
Infectious* nonanatomical waste		Yellow
Sharps and similar waste		"Sharps" or recognized symbol
Chemical/ Pharmaceutical waste	Chemical waste Pharmaceutical waste excluding cytotoxic Pharmaceutical waste	Black, Dark green, or recognized coding
	Cytotoxic pharmaceutical waste	Cytotoxic hazard symbol
Radioactive waste		Radiation hazard symbol
Pressurized container waste		Black or Dark Green
General waste	Office waste	Black or Dark Green
	Kitchen waste	Black or Dark Green
	Nonclinical glass waste	Black or Dark Green
	Noninfectious nonanatomical waste	Black or Dark Green

* Chemical or radioactive solutions containing human/animal and infectious nonanatomical wastes should be considered as chemical or radioactive wastes respectively.
Source: Canadian Standards Association, 1988.

2.7.2. Classification of hospital waste by WHO

The W.H.O. classified health care and hospital waste into eight principal categories:

a. General waste

Contains domestic-type waste, packing materials, non-infectious animal bedding, waste water from laundries and other materials that do not pose a particular handling problem or hazard to the environment or to human health.

b. Pathological waste

This type of waste includes tissues, body parts, organs, animal carcasses and human foetuses, body fluids and blood.

c. Infectious and Potentially Infectious waste

This group consists of cultures and stocks of infectious agents from laboratory work, waste from infected patients in isolation wards, waste that has been in contact with infected patients undergoing haemodialysis, waste which has been in contact with animals inoculated and suffering from an infectious disease and waste from surgery and autopsies on patients with infectious diseases. Infectious waste includes sufficient concentration or quantities that exposure to it could cause in disease.

d. Chemical waste

This type of waste includes discarded chemicals in solid, liquid and gaseous, forms, for instance from diagnostic and experimental work, housekeeping, disinfecting procedures and cleaning. Chemical waste may be hazardous or nonhazardous. Nonhazardous chemical waste includes chemicals other than those defined as hazardous chemicals such as amino acids, sugar, organic and inorganic salts. Hazardous Chemical waste is considered to be material that is:

i - Toxic,

ii - Corrosive (acid of PH<2.0 and bases of PH>12.0),

iii - Reactive (explosive, shock sensitive, water reactive),

iv - Flammable,

v - Genotoxic (teratogenic,carcinogenic, mutagenic or otherwise capable of modifying genetic material for example, cytotoxic drugs).

e. Radioactive waste

Radioactive waste comprises solid, liquid and gaseous material contaminated with radionucleotides generated from in vitro analysis of body tissues and fluid, in vivo body organ imaging, tumour localisation and therapeutic process. All radioactive waste can be considered to be hazardous.

f. Pharmaceutical waste

This kind of waste contains pharmaceutical products, chemicals, drugs that have been returned from wards, have been spilled, are contaminated or out dated, and many items which are to be discarded because they are no longer required.

g. Sharps

Sharps include syringes, needles, saws, scalpels, blades, broken glass, nails and other items that could cause a cut or puncture to human skin.

h. Pressurised containers

Pressurised containers consist of those used for demonstration or instructional purposes, including inert gas or innocuous and aerosol cans that probably explode if incinerated or accidentally punctured (WHO, 1985 a).

2.7.3. Classification of hospital waste by the United Kingdom

In the United Kingdom the Health and Safety Commission categorises clinical waste as follows:-

Group A

(a) Soiled surgical dressings, swabs and all other contaminated waste from treatment areas;

(b) Material other than linen from cases of infectious disease;

(c) All human tissues (whether infected or not), animal carcases and tissues from laboratories, and all related swabs and dressings.

Group B

Discarded syringes, needles, cartridges, broken glass and any other sharp instruments.

Group C

Laboratory and post-mortem room waste other than waste included in Group A.

Group D

Certain pharmaceutical and chemical waste.

Group E

Used disposal bed-pan liners, urine containers, incontinence pads and stoma bags.

Figure 2.7.1 illustrates a classification of hospital waste by method of disposal in the United Kingdom.

2.7.4. Classification of hospital waste by the former West German Government

West Germany's National Health Department has established four categories of hospital waste: general (including office and cafeteria refuse), "awkward and ugly" (blood spattered items that are not infectious), infectious and pathological (body parts).

Figure: 2.7.1 Classification of hospital waste in the UK

Non-infectious waste		Infectious waste	Special disposal
Refuse tip	Incineration plant	Incineration (after pre-treatment in autoclaves in some cases)	
1	2	3	4
Glass	Lubricants and fats.	Blood	Di-iso propyl
Paper	Pig carcasses.	Urine	Fluorophosphonate
Food	Waste with low	Pus	Diethylbarbiturates
Boxes	radioactive content.	Mucus, feces	Cyanogen bromide
Metal goods (except beryllium).	Medicaments which have lost their efficacy.	Foetuses	Thiophosgene
		Human tissue and limbs	Di-cyclo hexyl di-amide
Textiles		Fluids from the brain and spinal cord	Tetrandrofuran
Plastics		Vomit	Acids
Flowers		Swabs, dressings and infected waste	Picric acid
Alginate gel		Syringes, sharp articles, catheters	Diamino benzidine
Dental impression material		Waste infected with hepatitis	NN-dimethyl-p-phenylene diamine - naphthyls
Dental appliances		Bacterial cultures (research laboratory)	
Photographic film		Air filters for bacteria and viruses	
Paraffin wax		Animal carcasses, animal feces	
Acrylic dust		Quarantine waste	
Methyl methacrylate		Plaster of paris dressings	
Aerosol cans			
Building and construction wastes (special precautions required for asbestos construction)			
Plaster models of the head (except X-ray material).			

Source: Lund, M.A., Harwell Laboratory, 1977.

2.8 Characteristics of waste

The characteristics of the waste, as determined by analysis, is the basis of consideration to be given to any process for its disposal. Because the composition of waste influences the method of collection, the design of a waste disposal plant is controlled by the composition of the waste. An estimate can be made of biologically active or other hazardous material that may effect the environment by waste disposal and an assessment can be made of substances available for re-use or recycling.

The most significant features of solid waste are density, combustion, moisture, combustible content and thermal values. Table 2.8.1 shows the percentage composition of mixed solid waste in the USA and Western Europe (Gilbertson, 1969; Barton, 1986).

Table 2.8.1 Composition of waste in the USA and Western-Europe

Combined solid waste content	USA		Western Europe	
	Range %	Average %	Range %	Average
Ash and furnace residue	3 -20	10	12 - 47	30
Free moisture	12 -30	20	15 - 35	28
Combustibles	50 -75	65	23 - 37	32
Non-combustibles	10 -45	23	12 - 18	14

source: Gilbertson, 1969.

The composition and weight of solid waste change quite markedly depending on the locality of collection and the time of year but Tables 2.8.1 and 2.8.2 can be considered to be typical. The United Kingdom produces 18-20 million tons per year of domestic waste whose average composition is shown in Table 2.8.4

Table 2.8.2 Typical UK waste household.

Waste household contain	Percentage
Metals (mainly ferrous)	9 %
Glass	9 %
Paper	32 %
Plastics	8 %
Vegetable	20 %
Dust and other	18 %
Textiles, other	4 %
Total	100 %

Source : Porteous, 1992.

It should be noted that these values can change by ± 15 % (Porteous, 1992).

During the past four decades the generation, distribution, and use of potentially hazardous materials has increased dramatically. Rising populations have needed more products and services which have resulted in the increased manufacture of synthetic substances. For example, the percentage of plastics has grown significantly in the Municipal Solid Waste (MSW) stream over the past three decades increasing from zero to about 9% of the MSW stream. The use of plastic clearly reflects changing consumer habits and life styles (Franklin Associates, 1986; Burlace ,1983).

2.9. Hospital waste handling, storage and transport

2.9.1 Introduction

Hospitals are the largest producers of clinical waste and therefore require a waste management system which controls handling, storage and transport. This usually begins in clinical departments and wards.

The aim must be the disposal and removal of the waste as hygienically and economically as possible and by methods such that the risk to health and environment is minimal. Packaging, storage, transport and ultimately disposal must all be linked. The most effective way of handling hospital waste should be incorporated into the initial plans for the institution and then be considered at all later stages of development. Factors to be considered include:

1- Estimates of the total expected solid waste generation.
2- The selection of methods and sizing of equipment for the final disposal of waste.
3- The assignment of sufficient space and planning of all physical features needed for the proposed waste-handling activities.
4- The determination of type, size and locations of original waste containers, transfer receptacles if needed, and transportation equipment (American Public Health Association, 1956).

2.9.2 Handling

WHO defined waste "handling" as the link between packaging, storage and transport. Various methods are available for ensuring effective handling and disinfection of infectious waste. Table 2.9.1 outlines many types of such methods including those for treatment, transport, and disposal (Cross and Robinson 1989).

A system for the collection of infectious waste must be devised which separates the harmful from the innocuous material and which further subdivides the harmful waste into categories for later treatment. Of major importance is the separation of infectious and pathogenic waste from the rest. When the amount and the composition of waste is known for a specific installation, it is necessary during handling to segregate it into various categories.

2.9.3 Segregation

Pathological and infectious waste must be segregated as high-risk infectious waste may initially have to be autoclaved, preferably at source, to reduce the risk to staff and patients.

TABLE 2.9.1 Alternative Methods of Transport, and Disposal of Hospital Waste

Type of Waste	Processing steps																					
	Storage of waste					Transport of Waste					Volume reduction (on-site)			Disinfection techniques						Disposal		
	Internal			External		Internal				External				On-site				Off-site				
	Red bag	White bag	Sharps container	Loose in container	Compactor	Carts	Hydraulically	Pneumatically	Chutes	Trucks	Incineration	Compaction	Wet pulping	Ster lization	Incineration	Irradiation	Chemical disinfection	Incineration	Sterilization	Sanitary landfill	Incineration	Recycle
Pathological waste	x					x			x		x			x	x	x	x					
Infectious wastes	x					x	x	x	x	x	x		x	x	x	x		x	x		x	
Administrative wastes		x		x	x	x	x	x	x	x	x	x	x							x	x	x
Boxes		x†		x†		x				x	x	x	x							x	x	x
Kitchen wastes		x†		x@		x	x			x			x							x	x	
Cans				x	x	x				x		x								x		x
Bottles				x	x	x				x		x								x		x
Syringes and medicines			x		x+									x	x	x				x	x	

* Assumes on-site handling and disposal of pathological waste
† Can be stored separately
@ Organic to sewer, inorganic in containers
+ Kept in sharps container through to ultimate disposal
Source: (Cross and Robinson, 1989)

2.9.4 Packaging the material

After categorising the waste, hospitals must package it safely before sending it to incinerators, or other facilities. For instance, sharps should be packed in puncture-proof containers for disposal. In Switzerland, for example, all instruments such as scalpels and needles must go into labelled containers. For extra protection, it is stipulated in Germany that only licensed hauliers operating marked, specially designated vehicles can collect hospital waste.

2.9.5 Storage

If hazardous material is to be stored it must be secure so as to avoid risk of contamination. General clinical waste requires no particular measures for storage and can safely be dealt with in the same way as general municipal waste. Recycling of non hazardous waste should be practised where feasible. The best method for storage and also for collection and transportation of clinical waste is the use of coloured plastic bags. The hospital central storage area for hazardous waste should be separated and located far from the nonhazardous areas and should be a covered and in a lockable enclosure.

2.9.6 Transport

Internally, waste is usually transported from its initial storage point to an assembly area or on-site incinerator by means of handcarts or trolleys. The ash then has to be transported for disposal to an incinerator landfill site or other disposal location. In some modern hospitals, pneumatic pipelines are used for internal waste transport. Waste being transported externally should be in covered lockable vehicles which should be cleaned and disinfected regularly and particularly before being used for transporting materials other than wastes. When pathological and infectious or other hazardous wastes are transported, the contents of all containers and their potential hazard should be identified in documents carried in the vehicle. For example in Germany, truckers must alert incinerators that shipments are on their way. Trucks then drive down a special entrance lane at the incinerator and dump their loads onto a conveyor belt used only for the hospital waste furnace (WHO, 1985c; Hershkowitz,1990).

2.10 Legislation

In the UK as in several other countries, the legislative requirements on local authorities with regard to waste management are undergoing continuous change. The existing situation is controlled by the Public Health Act of 1936. The Control of Pollution Act (1979) obliges Waste Disposal Authorities to licence publicly and privately operated waste disposal plants. Many Acts between these two laws also affect waste management.

Under the Refuse Disposal (Amenity) Act 1978, the local authority has a duty to provide facilities to enable the public to dispose of waste. Hazardous waste is fundamentally a 'special waste' as defined in the Special Waste Regulations 1980 with 3 exceptions. These exceptions contain certain acids/alkalis, medical waste and many solvents.

In 1982, the Control of Pollution (Special Waste) Regulation 1980, was legislated under section 17 of the Control of Pollution Act. At the time the association of County Councils called the new system: "Unworkable, inadequate and virtually unenforceable" and described it as a 'Cowboys Charter'. The former legislation (Deposit of Poisonous Waste Act, 1972) had made it illegal to dump wastes in general but made no provision for hazardous waste (Anon, 1981). This legislation may be strengthened in the future to include all special waste (Turvey, 1990). The Environmental Protection Act 1990 received Royal assent on 1st December 1990 and comprises nine parts and 164 sections.

Part 1 : Integrated Pollution Control and Air Pollution Control by Local Authorities.

Part 2 : Waste on land.

Part 3 : Statutory Nuisances and Clean air.

Part 4 : Litter.

Part 5 : Amendments of the Radioactive Substance Act 1960.

Part 6 : Genetically modified organisms.

part 7 : Nature conservation Great Britain and conservation matters Wales.

Part 8 : Miscellaneous.

Part 9 : General. (Anon, 1991).

In the course of a survey (Commission of the European Communities, 1982) it was found that governments of almost all Member States of the EEC were working on the problems of hospital waste disposal. In the countries of the EEC there is no specialized legislation relating to hospital waste, also there is no trend to specialize the waste disposal laws, except in the UK. In Great Britain under section 30 of the Control of Pollution Act 1974 "controlled wastes" are sub- divided into:

a. Household wastes,

b. Waste from industries and

c. Commercial sources.

Of importance is, subsection 3a of section 30 which defines the term domestic waste: " It comes from dwellings, parts of universities, schools and other educational establishments and from parts of hospitals and nursing homes." The term "part of a hospital" is not defined. The Control of Pollution Act 1974 does not give a comprehensive listing of all waste types. Unfortunately it was not until 1988 that regulations were released giving a more detailed picture of pollution control. So until then and to a certain extent, since, the law has been open to interpretation and abuse for example: "Almost all the hospital incinerators in the UK are operating illegally" (Tickell & Watson, 1992). Also only those disposing of waste produced on the premises and able to incinerate no more than 200 kilograms per hour do not need to be licensed. However, the majority of hospital incinerators incinerate between 200 and 500 kilograms per hour and dispose of waste from nearby hospitals.

The first legal definition of clinical waste in UK was given in the Collection and Disposal of Waste Regulations (1988), as follows:

Any waste which consists wholly or partly of human or animal tissue, blood or other body fluids, excretions, drugs or other pharmaceutical products, swabs or dressings, or syringes, needles or other sharp instruments, being waste which unless rendered safe may prove hazardous to any person coming into contact with it; and any other waste arising from medical, nursing, dental, veterinary, pharmaceutical or similar practice, investigation, treatment, care, teaching or research, or the collection of blood for transfusion, being waste which may cause infection to any person coming into contact with it (HMSO, 1988).

Until 1991, hospitals could not be prosecuted for any contravention of environment law. As government property, they came under the Protection of the Sovereign, enjoying what is known as "Crown Immunity". The National Health Service and Community Care Act of 1990 deleted this immunity, and since April 1991 the whole of the National Health Service, hospitals included, has been subject to the full force of environmental law. From 1st April 1992, the executives of health authorities and hospital managers have become personally responsible for violations of the law. The next step in a four year programme of phased improvements introduces lenient temporary standards, and requires environmental health officers and health authorities to allow a strategy for meeting the final deadline in 1995. Hospitals from 1st October 1992 will be encouraged not to run incinerators that do not meet fully the standards laid down in the 1990 Act. It should be possible to improve standards at a reasonable cost (Tickell & Watson, 1992).

CHAPTER THREE

WASTE MANAGEMENT (TREATMENT AND DISPOSAL OF WASTE)

3.1 Introduction

Waste disposal plays an increasingly important role in the overall protection of our environment. The efficient disposal of hospital wastes since many of these wastes are contaminated and potential pollutants of air, water and soil, is an important factor in Man's environmental well-being.

The previous chapter discussed waste, hospital waste and other kinds of waste. In this chapter the study investigates common waste disposal methods and their advantages and disadvantages in the context of hospital waste. Finally it will discuss incinerators with particular reference to hospital incinerators.

3.2 Methods of disposal

The system of disposal depends to some extent upon the type of waste involved. A huge range of technologies are either ready or potentially ready for the management of municipal waste. These technologies can be classified under a number of headings:

a. Processes for final disposal, either of all the waste or of any residue remaining after earlier treatment.
b. Treatment to achieve volume reduction prior to final disposal.

c. Separation of the organic from the inorganic fraction of the waste.

d. Recovery of materials from the organic fraction or the inorganic fraction.

e. Reclamation of the organic fraction to generate either a fuel or a chemical product.

Table 3.2.1 illustrates the common processes (Wilson, 1981).

Table 3.2.1 A classification of Waste Management Technologies

General aim of process	Process	Comment
Final disposal	Landfill	A transfer station may be used with distant landfill
	Sea disposal	No longer used for municipal wastes
Treatment	Pulverization	Wet or dry process
Volume reduction -prior to landfill	High-density -baling	Bales may be self-sustaining or require wiring
	Incineration	Many alternative furnaces available
Energy recovery from unprocessed waste	Incineration	With heat recovery as steam or electricity
	Pyrolysis and other process	Some variants accept unprocessed refuse (see below)
	landfill	With collection of gas from anaerobic decomposition of the waste
Separation of organic and inorganic fractions	Dry separation	Uses some combination of shredding. air classification. magnetic separation and screening. Many proprietary variations

Table 3.2.1 continued

	Wet pulverization	Uses a rotary drum pulverizer with one or more screens for the output
	Wet pulping	Waste converted to a water slurry. organic pulped and inorganic separated by centrifugal action
Materials recovery from inorganic fraction (or from incinerator residue)	Magnetic separation	Ferrous metals. May be applied to pulverized or unprocessed waste
	Non-ferrous metal separation	Uses eddy current, electrostatic, or heavy media separators
	Glass separation	Uses some combination of screens, jigs, hydraulic classifiers, roll crusher, froth flotation and optical (colour) sorting From dry separation, by hand picking or air classification
Materials recovery from organic fraction	Paper and plastics recovery Paper fibre recovery	Wet pulping was originally aimed primarily at paper recovery. Several other approaches are now being developed
	Composting	Produces humus for use as soil supplement. Many variations using both mechanical high- rate and traditional windowing methods
	Wallboard production Annelidic recycling	Using a dried organic fraction or compost Uses earthworms to convert organic wastes into a fertilizer (worm casting) and protein (dried earthworms)
Energy (or chemical) recovery from organic fraction	RDF as supplementary boiler	Wide variation output from of solid refuse-derived fuel (RDF) depending on particle size. moisture content, freedom from inorganic contaminants and separation of paper/plastics from putrescible organic
(a) Combustion	RDF as supplementary fuel in cement kiln	Ash incorporated in cement product

Table 3.2.1 Continued

	Incineration of RDF	With heat recovery as steam or electricity. RDF may be find in suspension or in a fluidized bed
(b) Pyrolysis and other thermal processes	Pyrolysis	Thermal decomposition in the absence of oxygen. Products are solid, liquid and gaseous fuels, the relative yields depending on process conditions
	Gasification	Partial oxidation, the heat of reaction being provided by combustion of some of the waste in air or oxygen. Product is a low to medium heating value gas
	Steam reforming	Reaction with steam, to produce gas rich in carbon monoxide and hydrogen
	Hydrogasification	Pyrolysis in a hydrogen-rich atmosphere to produce a medium heating value gas
	Hydrogenation	Pyrolysis in a hydrogen-rich atmosphere under pressure to produce a liquid fuel
	Wet oxidation	Oxidation of a wet slurry of organic wastes with oxygen at high temperature and pressure. Main product is a solution of low molecular weight acids
(C) Bioconversion	Hydrolysis	Acid or enzyme chattelized hydrolysis of cellulose to produce sugars,which can be fermented to yield e.g.ethanol or single cell protein (yeast). Alkaline hydrolysis could yield organic acids for recovery to produce methane
	Anaerobic digestion	
	Biophotolysis	Sunlight induced intra-cellular enzymatic reduction of water to produce hydrogen gas

Source: Wilson, 1981.

In general there are two basic methods for the disposal of solid waste namely landfill or incineration followed by landfill. A difference of subsidiary processes, such as composting or pulverizing, may also be practised. Three general types of treatment are appropriate for treating hospital waste:

a. Heat treatment, for example: incineration, dry heat, steam heat.
b. Chemical treatment.
c. Irradiation.

In my opinion each of these techniques has its advantages, disadvantages and is suitable for treating different types of hospital waste. The art of waste management is to find the best methods of controlling, recycling or disposal of wastes cheaply and safely. Here I propose to discuss the following methods of waste disposal: landfill, sea disposal, composting, recycling and incineration.

3.3 Landfill (controlled tipping)

In the United Kingdom, the term "controlled tipping" is analogous to the U.S.A. use of "sanitary landfill" (Warner et al., 1970). Controlled tipping is the term employed for the disposal of waste (refuse and other waste) on land, and is still by far the cheapest in many places. This technique uses established and recognised means to prevent the problems associated with uncontrolled dumping.

Controlled tipping must be very carefully carried out because it can create a considerable nuisance to human beings, the environment and is even a danger to health.

3.3.1 Advantages and Disadvantages of landfill (controlled tipping)

The advantages of landfill (controlled tipping) are:

a. It is the cheapest method, but when all short-term and long-term costs are considered, it may not the most economic.

b. Simple operation is needed to run the site. Although discipline and proper tipping procedure is required the operation can be done simply and effectively.

c. The third advantage of landfill activities is that if properly planned, the biomethane generated can be collected and piped. This gas (methane) can be used as an energy resource.

The disadvantages of landfill (controlled tipping) are:

a. Large amounts of land are demanded.

b. Winter operations can be very difficult.

c. Prevention of ground water pollution may be costly.

d. Sites located outside of a city are often at a great distance from the source of the waste.

e. Other problems associated with controlled tipping, are the presence of noxious insects, mice, rats, and refuse which can be blown from the tip surface (Baum Bernard, et al., 1973; Tillman et al., 1989).

Landfill is good for bulky innocuous waste such as domestic waste. Contamination of this method of disposal should be considered. Hence, landfill is not a suitable method for hospital waste.

3.4 Sea disposal

The sea's huge capacity to absorb waste is largely used throughout developed countries, but if this unique resource is to remain a healthy and effective method of disposal it must be protected. Disposal of waste at sea takes two forms:

i. Dumping of waste at sea, either pre treated or not.

ii. Incineration at sea.

I will not discuss sea disposal widely but should mention some points about this waste disposal method. In sea disposal it must be ensured that:-

i. Material dumped as sea does not come back to land and there is no public health risk.

ii. There is no impact on fishing.

iii. There is no other serous environmental impact. There is some opposition to this method. For example one argument against it is based on the possibility of unburnt toxic material from seaborne incinerations being absorbed by microscopic organisms and entering the food chain (Matthews, 1987). There are many factors that can influence the impact of sea disposal. Chemical conditions, biological productivity, water circulation and marine life are some of them.

Sea disposal of US radioactive wastes from medical research activities etc. was discontinued by the US Government in 1967. In the UK, the main Acts concerning sea water quality are the Dumping at Sea Act 1974; and the Control of Pollution Act 1974 and the Food and Environment Protection Act 1985. This legislation considers both the dumping of wastes at sea and standards of marine incineration. Also the UK is a signatory to the Oslo Convention for the protection of the North Sea and North East Atlantic.

3.5 Composting

Composting is the thermophilic decomposition of organic solid wastes. It is a biological process where fresh organic wastes are transformed by decomposition into a stable humus-like substance. It can take place in two ways, either aerobically or anaerobically according to the biochemical nature of the bacteriological processes involved. This method is more costly than the use of landfill and it has certain disadvantages from the public health point of view (Skitt, 1972). For example, the material discharged from a composting plant normally demands maturing on open land for a long time to allow biological action to take place. Also it is difficult to obtain satisfactory labour and adequate supervision of plants and there is normally a detraction from the amenities of an area because of the smell and blown paper nuisance. Furthermore, rats, birds, larvae and fires can also be a problem.

3.6 Recycling and Recovery

Recycling refers to the process of making a substance which has become a waste available for further use. All waste disposal methods have disposal as the primary aim and the recovery of useful substances is of secondary significance. There are five techniques for recovery and use of waste as follows:-

- Materials recovery
- Chemical processes
- Compost processes
- Pyrolysis processes
- Energy recovery

The materials recovery and chemical processes are not discussed in this study but composting was discussed in section 3.5 and pyrolysis processes are discussed in section 3.9.1.

The calorific value of waste is now greater than in the past, for example, the value of urban waste, has now passed 9187 Kj/Kg (2200 Kcal/Kg). This waste thus has almost the same calorific value as young brown coal which, despite its low heat content, is used in some countries for generating electricity (Holmes, 1981) "The benefits of high quality waste incineration particularly with heat recovery are completely accepted and the many fine examples of European waste incineration plants are testimony to high standards of design and execution." (Holmes, 1981).

A related topic is energy reclamation, this means the recovery of heat from incineration in a form for reuse. The continued rise in the price of energy and the costs and problems involved with the use of conventional disposal methods for hospital waste are being increasingly called into question. Energy reclamation offers many advantages for instance:-

1- Reduced disposal cost

2- Energy saving

3- Reduction in environmental damage

4- Employment

Some waste substances from hospital activities may also be suitable for conventional recycling if kept separate from likely hazardous material.

3.7 Incineration

The idea of burning waste is not new. The technology has been used for a very long time. It is one of the oldest forms of waste disposal. Its origin dates back to the time when Man found that he could warm himself by burning the things he had hitherto dumped on the ground near his cave.

Incinerators were probably developed at a time when human beings first started to live in cities. In the USA the first incinerator was built on Governor's Island, New York Harbour, in 1885. The first municipal incinerator was a 30 ton per day garbage crematory constructed in Pennsylvania in 1885. According to Baum et al., (1973) there were three organised methods of refuse incineration in Europe, by about 1948:

a. Cell furnaces - the system of Heenan and Froude, used in Worcester.
b. Rotary Kilns - the system of Volund, used in Copenhagen.
c. Shaft furnaces - the system of Didier, used in Stettin.

In the United States, until the 1960s dumping and incineration were the primary methods of waste disposal. More recently the environmental awareness of the public and the subsequent legislation and regulations governing waste disposal have required the upgrading of existing waste dumps to landfills and the protection of ground water from contamination (Oweis, 1990).

Incineration is a process of igniting and burning solid, semisolid and gaseous combustible waste to produce mainly carbon dioxide and water vapour. It is essentially a process of heat induced oxidation using atmospheric oxygen. The process not only reduces the volume of waste but, both chemically and by the presence of heat, sterilises harmful biological agents.
In addition, the heat generated by incineration often breaks down toxic chemicals. Incineration is not a final disposal method since it produces a solid residue or ash which must be landfilled or otherwise disposed of safely. According to the literature, incineration is a comparatively safe and effective form of destroying infectious waste and contaminated material. Public risk perceptions may distort the reasonable management of risk; as one study has noted, there is a danger of strong but uninformed public pressure making technically appropriate facilities unavailable.

The employment of marine incineration in Great Britain is limited. In 1988, only 5,500 tonnes of waste were incinerated at sea which represents only 1% of all substances disposed of at sea (Department of Environment, 1989). The use of incineration at sea is being phased out by the UK Government; a complete ban was in place in 1991.

The incineration of solid waste has become popular in many countries. Municipal Solid Waste (MSW) is generated in Japan at the rate of 120,000 tons/day, with about 70% burned and the rest subjected to landfill. The largest incineration units have a capacity of 500 tons/day, while the largest incineration plants may have six 400 tons/day units (Jumpei Ando, 1989). In the UK the latest available data (1986-1987) indicates that the majority (83%) of hazardous waste is disposed of by landfill, 8% by marine disposal, 7% by chemical or physical treatment, and only 2% by incineration (British Medical Association, 1991).

3.7.1 Combustion

Combustion normally uses fuel or waste and oxygen. The oxygen normally comes from the air which contains, by volume, about 79% nitrogen and 21% oxygen. As a simplification, the combustion process can be defined as:-

C (in the fuel/waste) + O2 (in the air) ---→ Co2 + heat

H(in the fuel/waste)+ O2(in the air) --→ Water vapour + heat

A sufficient furnace temperature is fundamental to efficient combustion. This temperature will depend on the incinerator design and type of waste. The incineration of waste takes place in three stages: i. evaporation of moisture, ii. distillation, iii. combustion proper. When good combustion occurs the three "Ts", temperature, turbulence and time are optimised in the combustion zone. Sufficient oxygen is necessary to ensure that combustion is complete. Failure to reach satisfactory standards for any of the three "Ts" can lead to problems.

a. Inefficient incineration will fail to destroy the primary material and therefore bacteria, viruses, and other infectious and contaminated material will remain.

b. The process may lead to the formation of new products such as the products of incomplete combustion (PICs). Under ideal combustion conditions, approximately zero volume of incomplete combustion products will be generated through the two mechanisms of oxidation and reduction. But the process can produce by-products and these combine with oxygen or hydroxide radicals to form compounds like formaldehyde, alcohols, ketones and acids (Edwards, 1977).

High-temperature plants have very special requirements; waste must be combusted for one minute in an oxiziding atmosphere at a temperature of 1200 °C (2160 °F), (to be discussed in more detail in incineration systems, in Section 3.7.2). These conditions are especially effective in the destruction of difficult materials, for example polychlorinated biphenyls (PCBs).

For effective incineration the type of material must be considered; for instance:-

i. The physical form of the waste eg., whether it is solid, liquid, or sludge.

ii. The total heat input including the thermal content of the waste.

iii. The particular performance requirements, such as whether 99.99% destruction for hazardous compounds is required.

3.7.2 Incineration systems

The typical route for solid waste through an incineration process starts when a lorry arrives in the reception area and is weighed before discharging to a bunker. The second stage starts when waste is transferred by crane from the bunker to the feed hopper of the furnace. The waste is then allowed to flow into the incinerator under its own weight. The furnace operates at a minimum combustion temperature of 950°C. The primary chamber operates at about 30% to 60% of the theoretical air requirements. Turbulence is a result, which prevents transfer of ash and particulate matter into the downstream chamber. A secondary combustion chamber follows the primary chamber. The secondary chamber operates at approximately 1000-1220° C (1800-2200° f) with adequate oxygen to ensure complete oxidation of the organic gases and volatilised compounds. The discharge gases from the primary furnace will consist of unburnt hydrocarbons, carbon monoxide, hydrogen, nitrogen, acid gases and water vapour. Finally the remaining waste is conveyed to a burnout location before the ash is discharged. Clinker or ash is collected from the grates by a conveyor for transportation to disposal site.

. Figure 3.71 a schematic of an actual system, which contains a feed system, incinerator, heat recovery system, quench system, emission control system and discharge stack. The combustion gases must be cooled before discharge through the stack; only six incinerators in the U.K. can do this (Parker and Russell, 1986).

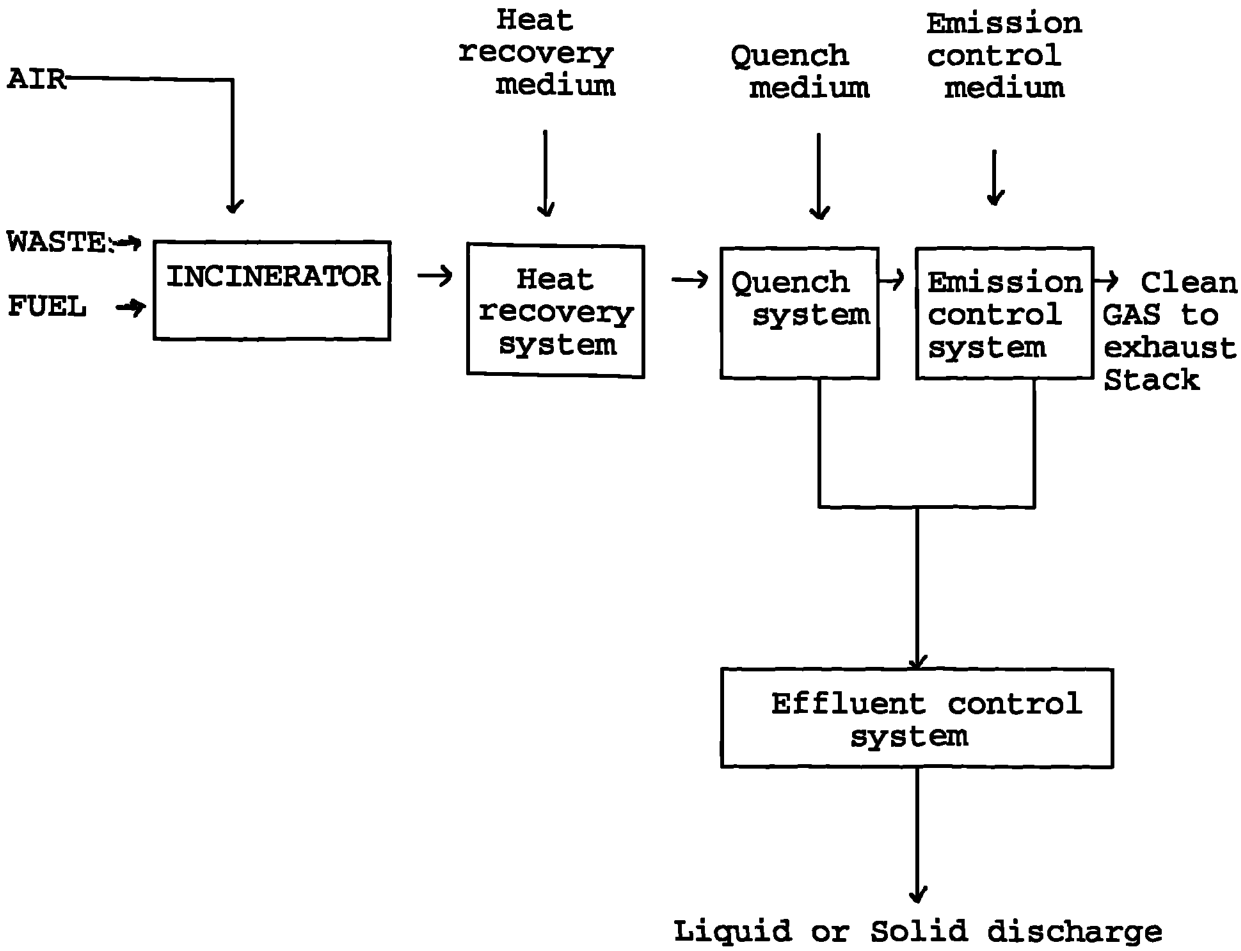


Figure 3.7.1 Generalised waste incineration system

Source: Kiang, 1980.

3.8. Incinerators

An incinerator is a chamber for burning fuel or organic waste. It is a simple device that subjects the waste to a high temperature, in a turbulent environment for the residence time needed to convert it into carbon dioxide and water vapour (Co_2 + H_2o).

As already stated in Chapter Two on the classification of waste the variety of material available for incineration is vast. The type of waste to some extent dictates the type of furnace to be used for its disposal. This section, therefore, reviews the types of incinerator and their methods of operation. An incinerator that is used to treat hospital waste may be situated on-site, at the place where the hospital waste is generated, or at some off-site location. Any incinerator may be used to treat hospital waste if it appropriately combusts the waste so killing the pathogens and destroying any biologically active substance that may exist.

Incinerators used for hospitals should contain two or three combustion chambers. The first chamber is of the controlled air type and the secondary chamber guarantees complete destruction of pathogens. Solids are heated to destruction in the first chamber. During normal operation temperatures in this chamber should range from 730-1040° C. In the secondary chamber there is a natural gas-fired after burner, and the temperatures should range from 650 - 1065° C. Stack gas temperature should range between 200-260° C at sampling ports located 2.0 m from the end of the stack (Allen and et al., 1986). Figure 3.8.1 shows a typical hospital incinerator system.

Furnaces which can be regarded as similar to hospital incinerators are found in crematoria for the disposal of human and animal bodies. There are 224 crematoria in Great Britain. These normally operate at temperatures ranging from 750-900° C (1350 - 1620° F).

3.8.1 Classification of Incinerator Systems

Many incineration technologies have been developed to burn waste. Details of the incinerators are available elsewhere (Hitchcock, 1979 and Freeman, 1989). Only a brief description is presented in this section. Also there are several categories of incinerator. For example Diamant (1974) classified incinerators according to size as well as quantity of refuse: small, medium and large. These are there basic types of incinerator:

a. Fixed grate system.

b. Moving grate system.

c. Grate-less system.

To some extent combustion temperatures differ according to the nature of the feed used but normally fluctuate between 800C° and 1000°C.

a. Fixed grate systems

These units are used mainly in hospitals, schools and old peoples homes because they are only appropriate for small refuse incinerators. According to Diamant (1974), where these are used for the combustion of industrial wastes, it should be similar in content to municipal waste.

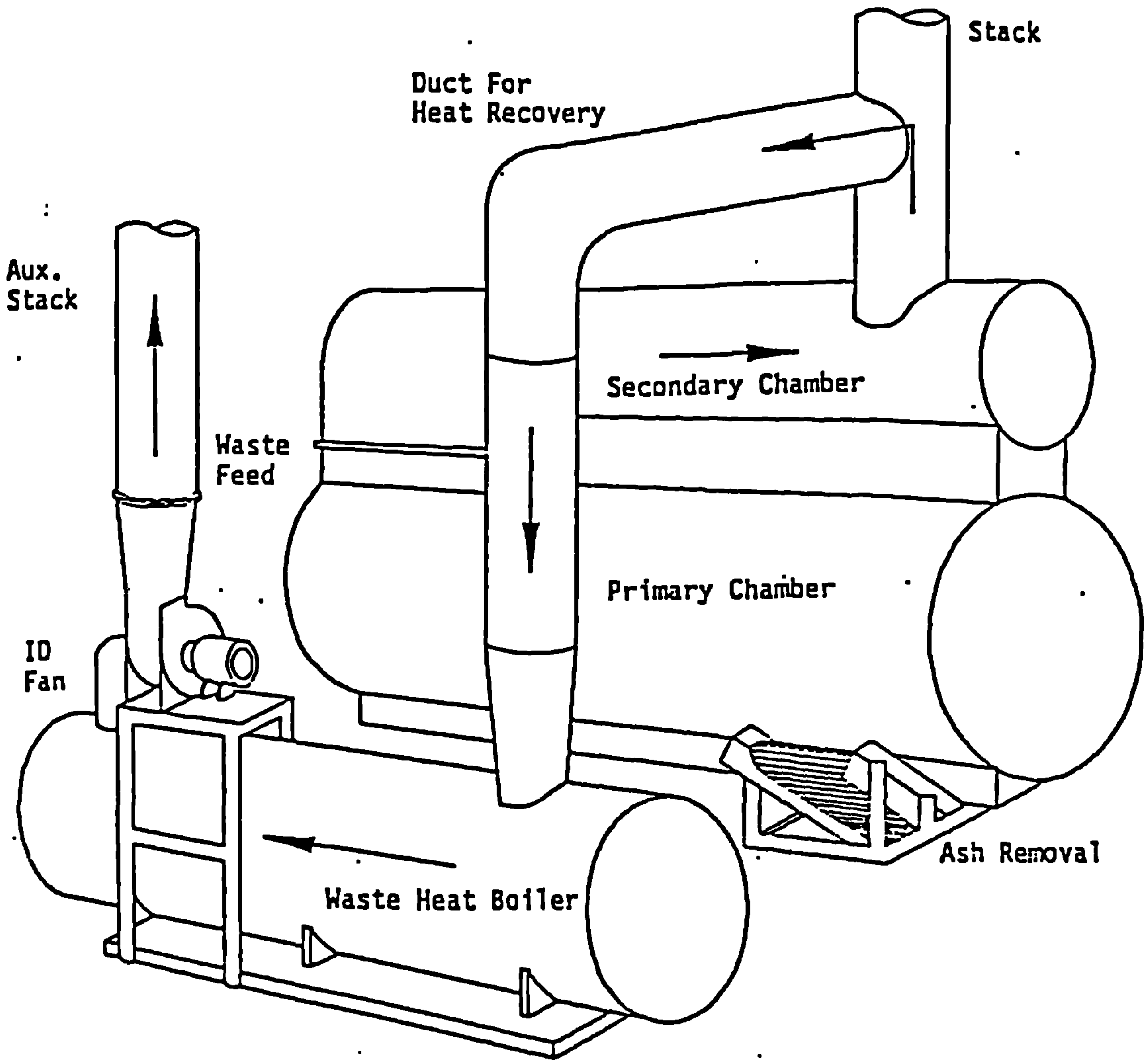


Figure 3.8.1 Typical hospital incinerator system.

Source: Cross, 1990

b. Moving grate systems

These are better for the combustion of changeable composition and changeable size classification refuse than the fixed grate burners. Moving grate systems can be subdivided into eight categories.

c. Grate-less systems

The simplest form of this type of incinerator is the shaft oven in which waste is burned in a vertical chamber. Different methods of agitating the refuse being used. The second type of grate-less system is the horizontal drum system. In this a rotating drum is employed with its axis inclined at a few degrees to the horizontal. The third type of grate-less system is the fluidized cyclone system in which it is necessary to pre-treat the material first by crushing or other methods of size reductions to ensure that the material enters as a fluid.

3.8.2 Classification of incinerators by EPA.

Incinerators can be classified according to the capacity for incineration per hour and the type of waste. Various types of incinerators are employed to handle liquid waste as well as waste in other forms, for example sludges, fumes, slurries and solids. The EPA (1988c) classified incinerators of which the main types are follow:-

a. Liquid or injection

This type incinerator is suitable for liquid or gas. The waste must be pumpable and atomizable. The burner has two components, an atomizing nozzle and a turbulent mixing section wherein atomized waste is mixed with sufficient primary air for complete combustion.

b. Gas or fume incinerator

This is very similar to liquid injection types, except that the fluid is in the form of fumes instead of a liquid. Engineers believe that this type of incinerator is simplest to design and operate.

c. Rotary Kilns

A rotary kiln is most effective for the destruction of solid wastes or sludge. The kiln is often as much as ten feet in diameter and more than forty feet long. The Kiln is a refractory lined steel cylinder, lying horizontally which rotates at very low speed and is mounted at a slight incline. Rotation of the shell causes mixing of the waste with the combustion air. It is usually large and flexible in scope but expensive to operate and maintain. It was first developed in the West German chemical industry in the 1960s by companies such as BASF and BAYER (Womann, 1971).

Combustion air is introduced at the burner end and combustion gases are exhausted at the opposite end of the kiln. A rotary kiln incinerator requires a secondary chamber to enhance the oxidation of the organic matter. Rotary kilns can destroy organic waste at temperatures over 1200°C (2248°F) with greater than 99.99% efficiency. Combustion temperatures vary according to the waste being incinerated, but normally range from 800°C to 1600°C (1500°F to 3000° F) with a residence time of up to two seconds. (Allen, 1989). Figure 3.8.2 shows a typical rotary kiln incinerator with secondary combustor.

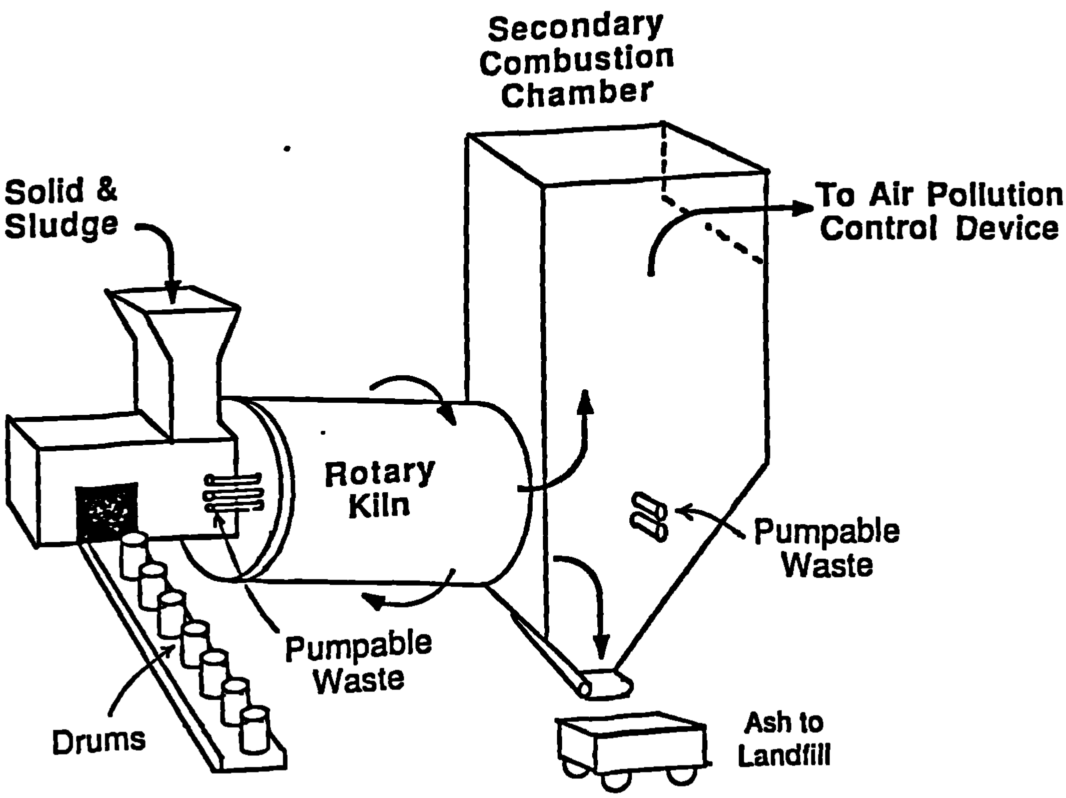


Figure 3.8.2 Rotary Kiln Incineration System

Source: Environmental Protection Agency, 1988a.

Although Rotary Kiln incinerators are capable of burning waste in practically any form, most U.S. rotary kiln incinerator manufacturers design their units on a non-slagging basis. The intention is not to melt any of the inorganic materials within the kiln. European kiln operators are generally very careful about the types and amounts of wastes that are fed into the incinerators. Because of concern about the emissions of heavy metals, rotary kiln incinerators typically operate at higher total exhaust gas flow rates than other types of incinerators operating on comparable waste materials.

d. Multiple chamber

Multiple chamber (hearth) incinerators have a vertical, cylindrical, refractory lined furnace with a moving shaft in the middle. The unit consists of two or more chambers. The primary chamber is used to pyrolyse solid waste and the secondary chamber is used to ensure complete combustion.

Typical substances burned in multiple-chamber incinerators are plastic wastes, such as polyvinyl chloride, epoxy, phenolic resins, acrylics and plant refuse containing garbage, wood, paper and rubber (Ottinger et al,1973). They are suitable for very high moisture content solid materials, which must be dried before these burn completely. They are primarily used for the disposal of wastes which are difficult to incinerate because of a high water content and can burn waste with a heat release potential of 26,500 KJ/kg of water and still maintain internal furnace temperatures between 1200 and 1500°F(640 to 1500°C), (Hitchcock, 1979).

Multiple hearth incinerators are more labour intensive than other incineration equipment because of the extreme variation in the form of feed waste and the special handling that this requires.

e. Fluidized bed

This type incinerator was developed from C.E. Robinson's patent for an ore-roasting furnace, with a bubbling-bed type fluidized bed. It has become the standard process reactor for coal gasification, catalytic caching of heavy oils, or roasting, calcining, cooling, drying, sizing and combustion. (Robinson, 1983).

The Fluidized bed incinerator is appropriate for hazardous and municipal waste. It is particularly suited to sludges and some kinds of organic-inorganic mixtures, since inorganic material will stay in the bed and can be removed as ash.

The fluidized bed incinerator consists of a bed of hot, inert aluminum or sand which is injected with air, see

Figure 3.8.3. In this type of incinerator operating temperatures vary depending on the particular application. For non hazardous-waste and sludges, the operating temperatures of the bubbling-type fluidized bed ranges from 650 to 1200° C (1200 to 2192° F) (Liao, 1974). Refinery wastes are combusted in fluidized beds that operate between 700 to 815° C(1300 to 1500° F), Ruble, 1974. For chlorinated solvents, destruction efficiencies greater than 99.99% are achievable in fluidized beds operated at 775° C (1427° F), Rasmussen and McFee, 1983.

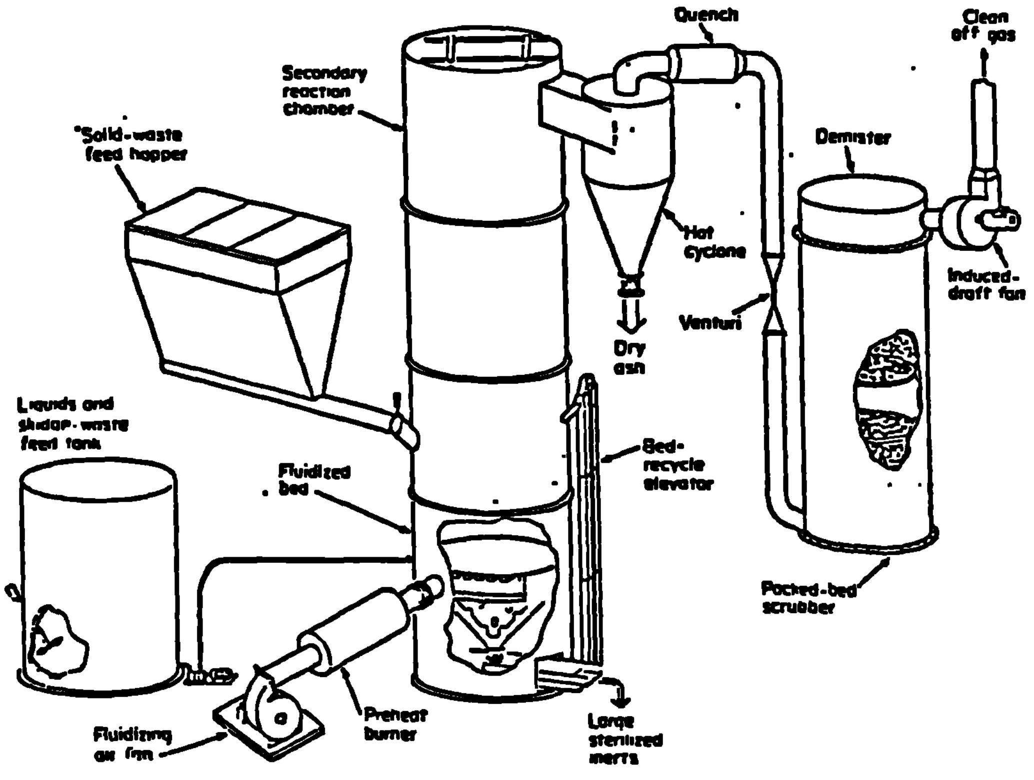


Figure 3.8.3 Fluidized bed system for combustion of hazardous waste. Source: Rasmussen et al., 1989

Air-emission controls for solid-waste incinerators are similar to those for liquid ones, except that particulate removal require more attention. The type of bed material can be used to control stack halogen, sulphur and phosphorus emissions.

The advantages of the fluid-bed design are lower excess-air requirements, better mixing between air and fuel and the ability to heat the fluidization air from the stack gas. Disadvantages of the fluid-bed incinerators are sensitivity to waste constituents and poor efficiency at reduced loading rates (Brunner, 1987).

f. Other types of incinerator

The main other types of solid waste incinerator which should be mentioned are, open burning, single-chamber and controlled air.

- Open burning consists of placing waste materials on the ground and burning them without the assistance of specialised combustion equipment.

- Single chamber incinerators, usually, do not meet the air pollution emission standards. This type incinerator may or may not have a firing system to ignite the waste.

- The controlled-air incinerator in general consists of a primary chamber followed by a secondary combustion chamber.

Properly chosen incineration technologies can effectively destroy hospital wastes. Also incinerators with appropriate air emission control systems can be harmless neighbours. In the UK the rotary kiln is the most generally accepted system for the incineration of hospital waste.

3.8.3 Incinerator stack emission

The potential effects caused by increased emissions of air pollutants from the growth in waste combustion is a key environmental issue. Pollutants discovered in the emissions can be evaluated with regard to three points:

1- Permanence in the environment.
2- Toxicity.
3- Potential threat to human health.

For example, 2,3,7,8 tetra chlorodibenzo-p-dioxin (2,3,7,8 TCDD), has been discovered in Municipal Solid Waste incinerators and in medical waste incinerator emissions. It is generally present in small quantities, but is so permanent and toxic that it is usually a primary cause of concern (Washburn et al, 1989; Murnyak, 1982). A summary of the typical contents of air pollutants from U.K.

Municipal Solid Waste in incinerators is as follows:- Volume gases, CO_2, HCl, SO_2, Particles, Pb, Cd, Tetrachlorodibenzo-p-dioxin (T4CDD), Terachlorodibenzofuran (T4CDF), Octachlorodibenzo-p-dioxin (EPA, 1986).

In the past two decades, poor operating practices in hospital incinerators have allowed extreme air emissions, including odours, particulate fallout, acid gas emissions and visible emissions. These emissions have been the outcome of overcharging the unit, poor adjustment of air, inadequate temperatures and poor design (Cross and Hesketh, 1990). For this reason, many developed countries have already enacted regulations or have draft legislation relating to hospital incinerators.

It has been supposed that all the pollutant emissions are aerosols and scatter as gases. This is true for HCl, SO_2 and some of the organic PIC's. Based on prevailing conditions chlorine, which is chemically bound within the hospital waste in the form of polyvinyl chloride (PVC) or other compounds will combine to form hydrogen chloride (HCl), providing there is hydrogen available. HCl formation is inhibited when excess air is added to the combustion chambers (EPA, 1988b). Considering the high hydrogen content of hospital waste owing to its high paper, plastics, and moisture content, there is a ready supply of hydrogen available for HCl formation (EPA ,1988b).

Other pollutants are generated in the incineration process, including oxides of sulphur, oxides of nitrogen and carbon based products of incomplete combustion such as polychlorinated compounds and traces of dioxins. Emission data is becoming available for an increasing number of British incinerators and has been reported in:- Clayton and Scott (1986a); Clayton and Scott (1986b); Clayton and Scott (1986c); Scott et al. (1986).

Sulphur dioxide is released or generated during the combustion process. The rate of sulphur dioxide emission is, therefore, directly proportional to the sulphur content of the hospital waste. The amount of SO_2 removal is expected to be meagre due to the high hydrogen chloride content of the flue gas. Because it is a stronger acid than SO_2, the hydrogen chloride will react more quickly with available alkaline compounds than SO_2 before they have a chance to react with the SO_2.

Nitrogen oxides are a mixture of NO and NO_2. In combustion systems, predominantly NO is produced because of kinetic limitations in the oxidation of NO to NO_2. Although the detailed mechanism of thermal NOx formation is not well understood, it is largely accepted that the thermal fixation in the combustion zone is described by the Zeldovich equations (EPA, 1988c).

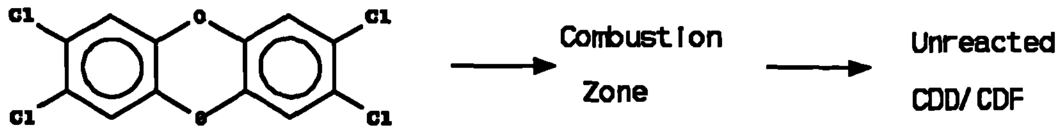
Particulate matter is discharged as a result of incomplete combustion and by the entrainment of noncombustibles in the stack emission. According to Edwards (1977), there are three general sources of particulate matter:-

a. Inorganic materials contained in the waste feed that are carried into the flue gas from the combustion process.
b. Organometallic materials formed by the reactions of the precursors in the waste feed,
c. Uncombusted fuel molecules.

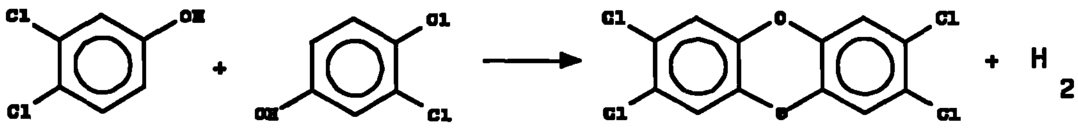
Inorganic substances are not destroyed during combustion and most of this material leaves the incinerator as ash. Some of this ash becomes entrained in the stack gas as particulate matter. The quantity of trace metals in the flue gas is directly related to the amount of trace metals contained in the incinerator waste. Some of the trace metal sources in the waste feed contain surgical blades, wrappers, foil, plastics and printing inks. Plastic objects made of PVC contain cadmium heat stabilizing compounds, and chromium, lead, and cadmium may also be found in inks and paints (EPA, 1988c).

The identification of potentially hazardous chemicals in stack emissions is very important in assessing the potential public health risks posed by a hospital incinerator. Pollutants discovered in the emissions can be evaluated with respect to toxicity and volume of release to determine their potential to threaten human health and persistence of pollutants in the environment. Attention must be taken in weighting these characteristics. For example, 2,3,7,8 Tetrachloro-dibenzo-dioxin (2,3,7,8 TCDD) which is one of the most toxic chemical substances discovered in hospital incinerator emissions, ordinarily exists in extremely small amounts, but is very toxic and so environmentally persistent that it is often the main problem for those who live near hospital incinerators. There are many different theories concerning the formation of dioxins and furans in incinerations. The best supported theories are shown in Figure 3.8.4 (EPA, 1988b). There is a growing consensus that the formation of dioxins and furans in combustion furnaces requires excess air (EPA, 1988b).

Figure 3.8.4 Hypothetical Mechanism of CCD/CDF formation

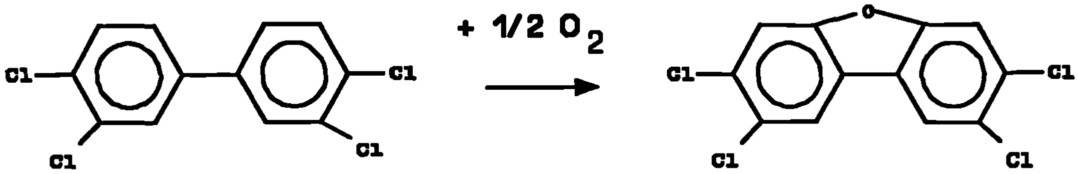


a. DIOXIN IN REFUSE



Chlorophenol Dioxin

b. FORMATION FROM RELATED CHLORINATED PRECURSORS

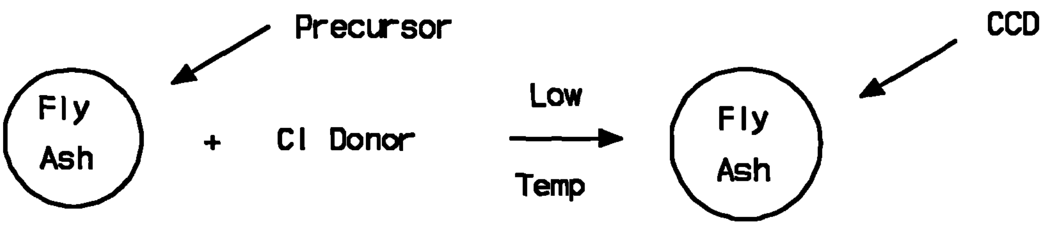


PCB Furan

c. FORMATION FROM ORGANICS AND CHLORINE DONOR

PVC	+	Chlorine Donor	CDD/CDF
Lignin		NaCl, HCl, Cl_2	

d. SOLID PHASE FLY ASH REACTION



Source: EPA, 1988c.

Table 3.8.1 contains a list of pollutants from the EPA study. The compounds shown in this table are those for which emissions data could be obtained for hospital incinerators.

It is not only the presence of halogenated substances in the hospital refuse which causes hazards but also those substances which produce toxic air contaminants leading to uncombusted residues (Doyle et al, 1985). Stack emissions from municipal solid waste incinerators may also include incomplete combustion residues of these potentially hazardous compounds because destruction of organics by incineration is never one hundred percent.

Hospital waste has a higher thermal value than municipal solid waste as it contains more plastic materials. Hospital waste usually has approximately 20 percent plastic, with levels as high as 30 percent being reported (Murnyak, 1982). In comparison, municipal solid waste usually has about 3-7 percent plastics (EPA, 1988b). In addition organic compounds generated by the combustion process are the products of incomplete combustion. These chemicals can be the generators of toxic pollutant emissions where high temperatures exist.

Municipal Solid Waste stack emissions may contain toxic metals which existed in the incinerator feed. For

Table 3.8.1 Pollutants measured/tested

Trace Metals	Polycyclic Organic Matter	Low Molecular Weight Organic Compounds	Acid Gases	Others
Arsenic	Dioxins	Ethane	Hydrochloric Acid	Particulate Matter
Cadmium	Furans	Ethylene	Sulphur Dioxide	Carbon Monoxide
Chromium		Propane	Nitrogen Oxides	Pathogens
Iron		Propylene		Viruses
Manganese		Trichlorotrifluo roethane		
Nickel		Trichloroethylene		
Lead		Tetrachloroethylene		

Source: EPA, 1987.

example, metals like lead, mercury and plastics (EPA, 1987). Many volatile metals, like mercury, tend to vaporise during incineration, and may then be emitted as vapours from the stack. Furthermore, unlike organics, metals cannot be decomposed by incineration. Other metals contained can include zinc, tin, silver and chromium which are extensively used in metal surface coating, galvanising and soldering (EPA, 1987).

Smith et al. report results from many studies showing typical plastic fractions of approximately 10% by weight. (Smith et al., 1975) Chloride emissions were estimated during one study of the waste from the Walson Army Community Hospital with about 30% plastics by weight (Murnyak, 1982), but previous studies had estimated 11% plastics by weight (Gordon et al.,1979).

Another study of Army hospitals reported that an average of approximately 19% by weight of Army hospital wastes are plastics (Gordon et al.,1980). At the Walson Army Community Hospital in the United States, chloride/chlorine emission from hospital's medical waste combustion were quantified in conjunction with a special emission stack test. For five sample runs, chlorine(Cl_2) emissions averaged 100.5 mg/m^3 with a standard deviation of 72 mg/m^3. Chloride emissions reported as HCl, averaged 5.4 mg/m^3 and posed a potential health risk (Murnyak,1982).

A 1980 test of a California pathological waste incinerator with a combustion capacity of 1300 lb/hr of hospital wastes, showed an average HCl emission of 1120 ppm for test runs (ECE Group LTD, 1984). In Germany other earlier studies of HCl acid gas emission from hospital refuse incinerators indicated that they emitted chlorine (Cl_2) waste gases that caused vegetation damage at two nearby farms (Bohne,1970).

3.8.4 Incinerator stack emission biological release to the environment

Bacteria and other pathogens occur in hospital waste. Hobbs and Roberts (1987) reported that food-borne pathogens could be classified in three categories according to the degree of hazard:-

1. Severe, for example Clostridium botulinum, which is rare but often fatal, and the enteric organisms and Vibriocholerae.
2. Moderate with a potential for spread, for example E. coli, Campylobacter, V.parahaemolyticus and many serotypes of Salmonellae.
3. Moderate with limited spread, for example, Bacillus cereus, C.perfringens type A and Staphylococci.

The bacteria found in hospital solid waste have been studied and pathogens higher than class two have not been reported. Class two organisms found were Moraxella sp., Escherichia coli, Klebsiella ;., Staphylococcus aureus and Salmonella (Gordon et al, 1980). This inventory includes those microorganisms discovered in hospital air, in addition, in leachates from lysimeters filled with hospital refuse and those isolated from hospital solid waste (Gordon et al., 1980). Class two bacteria correspond to a wide spectrum of indigenous moderate-risk agents present in society associated with human disease of varying severity (Department of Health and Human Services, 1978).

In a study by Gordon et al., (1980), the solid waste of a teaching hospital was studied for the existence of pathogenic microorganisms. Waste from three areas of the hospital were examined:

i. The incinerator room,
ii. General medicine areas and,
iii. The blood bank.

Staphylococcus, Bacillus sp and Streptococcus were among the majority of micro organism isolated (Gordon et al.,1980).

In another study by Barbeito and Shapire (1977), B. subtilis. spores were gathered from stack gas by the filtration method when a portable pathological incinerator was being tested to decide a minimum operating temperature (Barbeito and Shapiro, 1977).

In a separate investigation by the United States Environmental Protection Agency, only two gram positive bacilli per cubic foot of air were present in the effluent from municipal incinerators (Environmental Protection Agency, 1970).

Allen et al.(1989) from the University of Illinois at Chicago, found only five references in the literature which gave an indication of the effectiveness of incineration for rendering infectious hospital waste innocuous. These studies indicate the potential for discharge of bacteria through the emission but as actual waste was not burnt at the time of the test in three of the five studies, the generalizability of the results are limited. One research was conducted on an operating hospital incinerator where hospital waste (including infectious hospital waste) was burned. Bacteria were collected from the stack gas, but not identified. "Thus this research also indicated the potential for release of bacteria stack gas, but,because the bacteria were not identified, it is impossible to determine the source of the bacteria (unburned waste or combustion air) or the impact on the surroundings" (Allen et al., 1989). These studies highlighted the problem associated with sampling bacteria from stack gas. The results were inconclusive and indicated that some bacteria might survive incineration. Allen concluded that further research was necessary in this area.

3.8.5 Solid ash residue

The first step in the assessment of the innate hazard of the solid residues is to determine the identity and quantity of particulate chemicals in the bottom ash and the fly ash. Solid residues generated by Municipal Solid Waste incineration can be classified as either fly ash (the fine particle matter collected from the air pollution control system and boilers) or bottom ash (that collected from the combustion grates). Bottom ash usually constitutes 70-90% of the total volume of solid residue generated by Municipal Solid Waste incinerators (EPA, 1988c).

In the United States, it is standard practice for Municipal Solid Waste and incinerator ash to be analyzed employing the extraction procedure (EP) toxicity test to determined the leaching potential of metals. By Federal drinking water standards, if the chemical concentration in the leachate simulated by the extraction procedure toxicity test exceeds predetermined criteria, the ash is determined as extraction procedure toxic. Information gathered up to 1987 indicated that the combined fly ash and bottom ash residues from most Municipal Solid Waste incinerators exceeded the extraction procedure toxicity test criteria for Cadmium and Lead (EPA, 1987).

3.9 A summary of other possible alternatives to incineration

The aim of treatment of hospital waste is to change the biological character of the waste to remove, or at least to significantly reduce, its potential for causing damage. In considering the most appropriate treatment and disposal methods for hospital waste, account should be taken of the existing local options. Several methods are discussed below. As stated earlier nonhazardous chemical waste can be disposed of along with general waste, but special measures are necessary for chemical waste of hazardous character. The two most common techniques used to treat infectious waste are incineration and steam sterilization. Other methods currently used are radiation, hydropulping, oxidation and microwaving. Environmental impact and economics are important in choosing a hospital waste treatment method, but they become meaningless if the technology itself is not perfect or is not effective. The main problem with incineration is emission control which many be solved by either reducing the emission or performing the process in an acceptable environment. Some of the possibilities are as follows:-

3.9.1 Pyrolysis

Pyrolysis is a thermal treatment process in an oxygen deficient situation, it is not an incineration process. The temperature for pyrolysis is lower than incineration, the operating temperature is usually around 800° C. The process is a physical and chemical decomposition of waste material which can lead to 90% waste reduction (Shah et al., 1989; Kharbanda, 1990). The main advantages when using pyrolysis for hazardous waste reduction are as follows.

1. The residue is innocuous, sterile, and in friable form.
2. The products can be easily handled and transported.
3. The low temperature compared to incineration means longer refractory life and reduced maintenance.
4. The volume of gases generated is considerably reduced, therefore huge savings in power and gas cleaning requirements result, whilst pollution is minimized.
5. The pyrolysis process is more controllable than incineration.
6. It is more compact and cheaper than an incinerator.

The pyrolysis method does however have a disadvantage which is the need to fume the incineration products of incomplete combustion, such as the principal organic hazardous constituents or carcinogens present in the hospital waste.

3.9.2 Sterilization

a. Steam Sterilization

Steam Sterilization is an oxidation process. Steam is passed into infectious waste in a pressurized autoclave to kill the bacteria by heat. Sterilization does not destroy waste. After sterilization waste must eventually be disposed of in a landfill. A review of the literature suggests that there may be some public health risk in using sterilization by autoclave. There are some wastes that should not be treated through steam sterilization, for example body parts, and large quantities of animal bedding all of which are generally high-density materials. Another consideration attending autoclaving all infectious hospital waste is that many bags are heavy and can burst and leak.

b. Ethylene Oxide Sterilization

Another way to sterilize infectious hospital waste is the use of Ethylene Oxide (ETO). Ethylene Oxide is an excellent sterilant and is ideal for hospital waste that cannot be autoclaved because it does not impair rubber or plastics and can penetrate muslin packaging and polyethylene to kill all known microorganisms (Glaser,1977). Ethylene Oxide is a colourless gas which liquefies at 10.4° C (760 mm Hg). Unfortunately ETO does present some adverse health risks, for example skin sensitization, eye irritation, diarrhoea, respiratory problems and vomiting (Glaser, 1977).

3.9.3 Radiation

"Radiation of bulk materials and medical applications using radionuclides have been used for some time. Now biological materials are being subjected to similar treatment. Radiation sources, such as cobalt-60, at source strengths of 100,000 curies are being considered" (Cross, 1990).

3.9.4 Wet Grinding or Hydropulping

Another method for the disposal of hospital waste is wet grinding. The advantage of this method is that it can reduce the waste volume and in addition provide for fluidized transport. This system has not been tested on a large scale. Further study is needed with a large hyropulping plant to determine if greater volumes of waste can be disposed of using this method. Experience has shown a difficulty in pulping plastics and cloth. Equipment failure was common and the separation of waste by this method has not always been successful (Cross, 1990). As grinders have the potential to aerolize infectious agents from hospital waste, for the protection of public health, it needs more research.

3.9.5 Microwaving

In the United States Microwaving is a technique which has recently been proposed. In this technique waste is irradiated with microwave energy to disinfect material. In the automatically controlled Sanitec Microwave Disinfection System crushing then reduces the waste volume by about eight times its original volume (Cross, 1990). Microwaving uses less energy than other disinfection methods, and is environmentally acceptable (Cross, 1990).

3.10 The proposed hospital waste disposal system at Kirkby

My study has been concerned with one application, that of the Waste Management Limited proposal to construct and operate a hospital waste incinerator at Hammond Road, Kirkby Industrial Estate, Knowsley, Merseyside. The plant (incineration unit) will consist of a two stream unit with a nominal capacity of about 1.2 tons per hour. In compliance with the latest proposals, each unit will consist of two chambers; a primary combustion chamber operating at a temperature of 900° C and a secondary, post combustion, chamber operating at 1100° C with a gas residence time of the order of two seconds so that incomplete combustion gases from the primary chamber will be totally destroyed.

The system will be operated by a microprocessor with a printout facility for all stored information. The incinerator itself will be composed of three distinct parts: (See Figure 3.10.1)

1 - Stationary pyrolysis zone (starved air combustion).

2 - An incineration zone for complete calcination of the residues of pyrolysis.

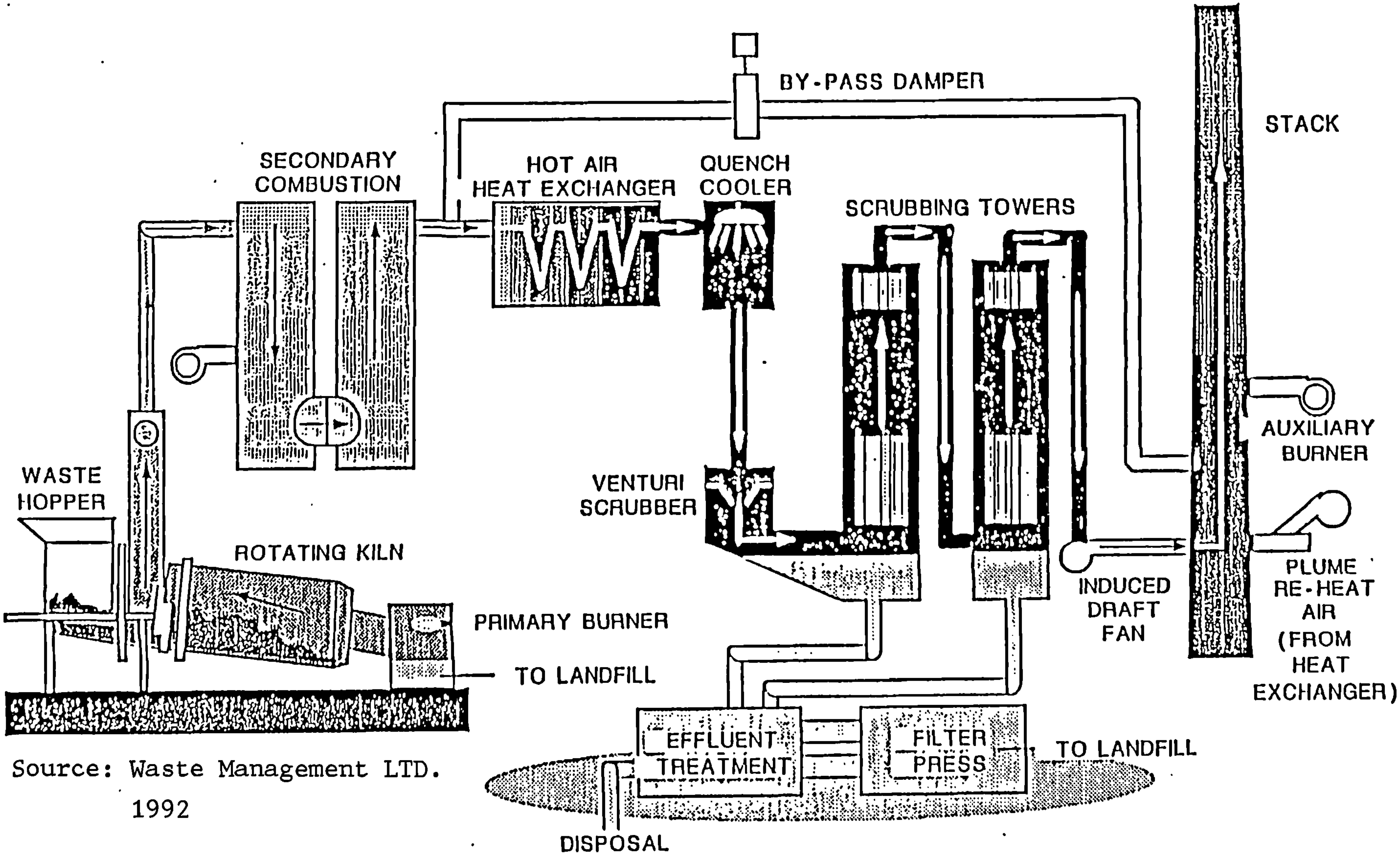
3 - An ash cooling zone with an automatic ash extraction system.

The maximum expected emissions at the chimney are:-

Gas flow	:2 x 12000 Nm3 /hr
Gas temperature	:80 ° C
Fly ash (particulate)	:50 mg/Nm3
Oxygen	:11 %
Cl _	:100 mg/Nm3
Br _	:25 mg/Nm3
F _	:4 mg/Nm3
Nox _	:100 mg/Nm3
Sox _	:100 mg/Nm3
Co _	:100 mg/Nm3
Cd, Hg, Tl	:0.1 mg/Nm3
As, Co, Se, Te, Ni	:0.1 mg/Nm3 (total)
Sb, Pb, Cr, Cn, Mn,Sn, Pt	:5 mg/Nm3 (total)
Temperature (minimum)	:100 ° C
Capacity Bacharach	:2 max.
Unburnt Particles in ashes	:3 % max.
Temperatures (min.) Incinerator	: 900 ° C

Figure 3.10.1

WASTE MANAGEMENT LTD CLINICAL WASTE INCINERATOR



Source: Waste Management LTD. 1992

Post combustion :1100 ° C (2 Second duration)

Scubbing Liquor :60 ° C

Maximum total fluorine content: 0.25 %

Electric Power Consumption :2 x30 Kwh

Fuel Consumption: * Start - up:2 x 75 Kg

* Normal working

Condition : Nil

Drain to the sewer : Nil

The emission velocity at the chimney exit will be about 13.5 m/Sec.

CHAPTER FOUR

RISKS FROM WASTE INCINERATION

4.1 Introduction

The present chapter attempts to present an overview of the available procedures for incineration and hazard assessment of hospital waste. This chapter discusses primarily risk and its assessment and perception. Risk can be considered from different perspectives which of necessity contains assessments of a number of factors. These include :-

a. Risks to human health (to be discussed in Chapter 9).
b. Risks to the environment, for instance hospital incineration impact upon flora and fauna (to be described in Chapter 9).
c. Risks to aesthetics.
d. Combinations of the previous three.

This chapter reviews some basic concepts of "Risk" in general, and the application of these concepts to the evaluation/ measurement of the risk of hospital waste incineration.

4.2 General consideration

The word 'Risk' probably originated in Greece or Italy. It is the probability of the occurrence of an undesirable future event. More exactly, risk is the probability or likelihood of the occurrence of some adverse impact (Lowrance, 1981). According to one definition, "Hazards are threats to people and what they value and risks are measures of hazards" (Kates and Kasperson, 1983). Risk can be defined as the probability of the occurrence of an event. A risk involves a combination of two factors:-

1. Probability or chance of an undesirable occurrence.
2. The severity of that occurrence (American Chemical Society, 1984).

The Royal Society (1983) defines risk as " the probability that a particular adverse event occurs during a stated period of time or results from a particular challenge". In this respect, risk is distinguished from a "Hazard" which is seen as follow:-
" The situation that in particular circumstances could lead to harm" (Royal Society, 1983).

Hazard is an always existent, inescapable part of life (Covello and Mumpower, 1985). According to Smith (1992), risk is sometimes taken as synonymous with hazard but risk has the greater implication of the chance of a special hazard actually occurring. Thus, we may define hazard as a potential threat to humans and their welfare, and risk as 'the probability of hazard occurrence'. The difference was nicely illustrated by Okrent (1980) who discussed two people crossing an ocean, one in a liner and the other in a rowing boat. The hazard (death by drowning) is the same in both cases but the risk (probability of drowning) is very different. If the drowning really happened, it could be called a disaster. So a disaster may be defined as 'the realisation of hazard'(Okrent, 1980).

Hazard, risk and disaster function on varying scales. In terms of reducing hazard severity, we can identify the following threats:-

a. Hazards to people - stress, injury, disease, death
b. Hazard to goods - property damage, economic loss
c. Hazard to the environment - pollution, loss of flora and fauna and loss of amenity.

Utilization of the theory of risk is mainly for persons or agencies who organize and develop the health and safety concerns of the public. Such agencies should be sufficiently informed of how the public thinks, responds and reacts to risk (Slovic et al., 1979; Slovic, 1987). The theory of Risk was developed by Bohlman in 1909. He prepared a mathematical analysis of random fluctuations in the insurance industry (Houston, 1960). Studies of risk have been applied to various activities ranging from hazardous wastes, to chemical and aviation industries. Risk theory is used as a tool to measure the subtle and complex perceptions that men have about risk.

There is no generally agreed definition of risk perception although risk assessment and risk perception have been systematically studied. International organisations have considered the process of assessment and risk management (World Health Organisation, 1985a)(The National Research Council (USA), 1983; Gratt, 1987; Ruckelshaus, 1983; Royal Society (UK), 1983. The definition of risk prepared by the Royal Society in 1983 has been interpreted in various ways. Three interpretations of the term have broad acceptance and this must be recognised and understood in order to appreciate the full meaning of the term. Fortunately, Lord Ashby (1982) defined these interpretations as follow:

> "Those of us who are familiar with the concepts of probability find its conclusions so persuasive that we are surprised how unconvincing they are to many people. It's useful at the outset to distinguish three common meanings of the word 'Probability'. It can refer to empirical results of observation, such as the statistics of road accidents; or logical deductions from reasoning (a point made by Venn over a century ago in his book 'The Logic of Chance')such as the fault-tree analyses in the Rasmussen Report on nuclear power; or it can express a belief, as you hear in American weather reports, when it is said that there is a 30% chance of rain. Degrees of belief are subjective and will differ even though based on the same set of data." (Ashby, 1982).

4.3 Acceptable risks

Two methods have been put forward for determining acceptable risks. Displayed preference methods, simplified by Starr (1969), trust in the analysis of previous behaviour in relation to risk to order future options. The alternative method employs psychometric approaches to determine what people consciously choose as acceptable risk (Fischhoff et al., 1978; Green and Brown, 1978; Slovic et al., 1979). According to Rowe (1977) displayed preference theory methods to determine acceptable risk are a beneficial way of creating hypotheses. As an intuitive technique it is insufficiently designed to test its own hypotheses, and readily degenerates into specious arguments (Green and Brown, 1977).

However, while nil risk is obviously the ideal, it is generally an unattainable objective. (Analytical methodology can detect some environmental contaminants in concentrations as low as parts per trillion). Understanding that the goal of nil risk is generally unattainable, risk management policy makers have discussed the concept of a de minimis or trivial level of risk with which society need not concern itself (Spangler, 1987).

According to Fischhoff et al. (1984) a decision-making perspective makes available a common language for treating some recurrent issues in acceptable problems, as illustrated in Figures 4.3.1 to 4.3.4. Assume that a single individual is permitted to make each decision, that all risks and costs can be identified, characterized, and assessed with confidence, and that the advantages of all the choices are identical. The choices differ only in their cost and level of risk; zero (0) is the best level for each of these dimensions. As concrete examples, consider an individual choosing among incineration or among landfill procedures that differ only in cost and risk.

Figure 4.3.1 illustrates how the set options considered affect the choice of the most acceptable option. If I (Incineration) and L (Landfill) are the only options available, then the choice is between high cost with low risk (I) and low cost with high risk (L). The level of risk accepted would then be that level associated with either (I) or (L), depending on which was chosen. If another option having lower cost and lower risk (M) became available, then it should be preferred to either (I) or (L). The risk approved would then be the level associated with the new option.

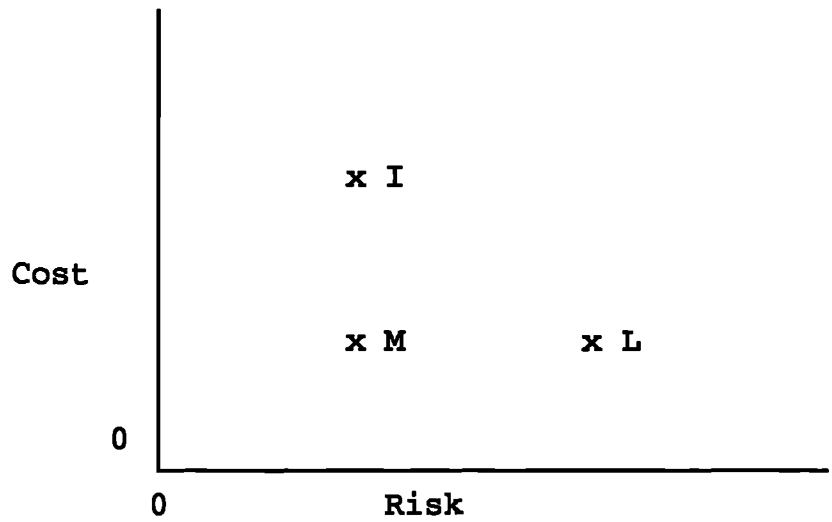


Figure 4.3.1 The effect of the options considered on the choice made. Source: Fischhoff et al., 1984.

Figure 4.3.2 shows how determination of the most acceptable option depends upon the decision maker's objectives. If the goal is minimizing risk, then option (Incineration) would be chosen. Minimizing cost, on the other hand, entails the choice of option (Landfill) and its higher level of risk.

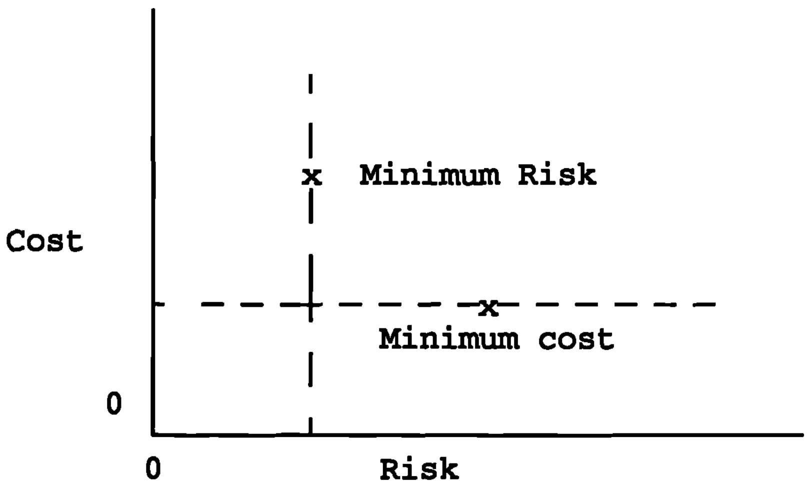


Figure 4.3.2 The effect of the decision makers values. Source: Fischhoff et al., 1984.

Figure 4.3.3 mitigates the assumption of complete information. New knowledge can greatly change the decision maker's appraisal of the costs and risks of M. Had M previously been chosen, then the accepted level of risk would prove to be much higher than that originally expected. If the decision had yet to be made, then the choice would return to I or L, with their accompanying risk levels.

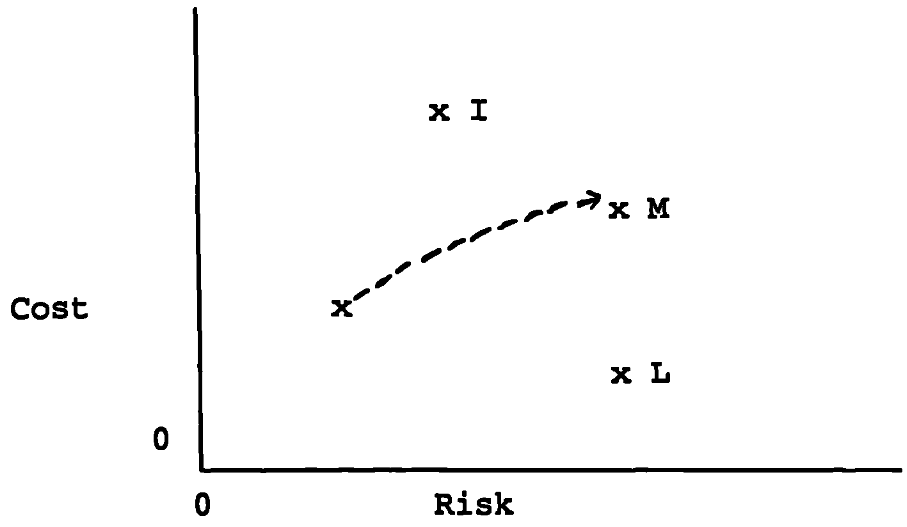


Figure 4.3.3 The effect of changing information.
Source: Fischhoff et al., 1984.

The decision formulas used in Figure 4.3.3, minimize cost and minimize risk, were rather simplistic. The two broken curves (indifference curves) in Figure 4.3.4 present more believable preferences. Any point on such a curve would be equally interesting to an individual whose preferences it represents.

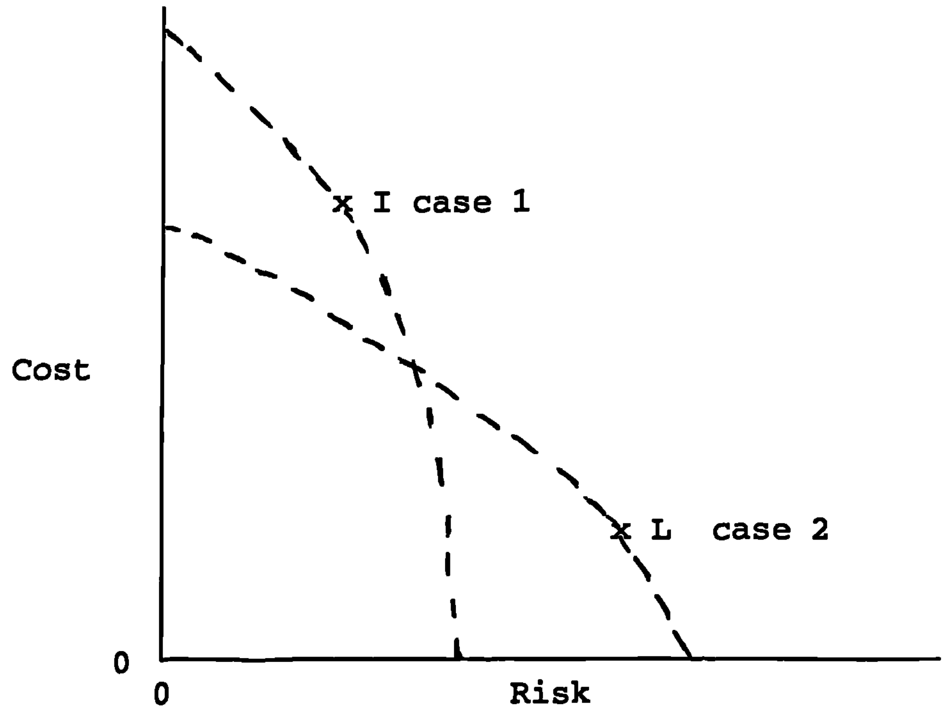


Figure 4.3.4 The effects of more complicated preferences.
Source: Fischhoff et al., 1984.

Case 1 demonstrates a willingness to suffer large costs in return for small reductions in risk. By this standard, option I is preferred to L; the cost saving of L is achieved at the price of too great an increase in risk. Actually, this individual would prefer I even if L's cost was zero. Case 2 demonstrate less willingness to increase costs in exchange for reduced risk; option L is now the best choice (Fischhoff,et al.,1984).

Therefore, the determination of acceptable levels of risk associated with an activity is a social process involving the balancing of costs, risks, and benefits whose distribution is often inequitable. Recognition of the problems in quantifying social variables and the impossibility of unanimous agreement on any social issue is a prerequisite for understanding what makes a level of risk acceptable. Thus, many risks are acceptable and some conditions that support this contention are evident, in the following:

1- A risk is unavoidable or uncontrollable without major disruption in lifestyle-status quo condition.

2- A risk is perceived to be so small that it can be ignored-threshold condition.

3- A risk is deemed worth the benefits by a risk taker - voluntary balance condition.

4- A credible organization with responsibility for health and safety has, through due process, established an acceptable risk level-regulatory condition.

5- A historic level of risk continues to be an acceptable one-de facto condition.

However, a risk is acceptable when those affected are generally no longer or not apprehensive about it (Rowe, 1977). In deciding what kinds of disposal we should use for hospital waste many environmental factors must be taken into account; but the risks to human life and health must always be the first consideration and may be overriding.

4.4 Risk perception

Perception of risk according to Slovic (1987) is the ability to sense and avoid damaging environmental conditions required for the survival of all living organisms. Survival is also helped by an ability to codify and learn from past experience. Humans have an additional capability that allows them to modify their environment as well as respond to it. This capacity both creates and reduces risk (Slovic,1987).

Perception is virtually never perfect, such as in the way that a photograph reproduces a scene. Perception is a highly selective, constructive and need driven activity which attempts to preserve the stability and constancy of the social and physical worlds (Handmer and Rowsell, 1990).

According to Shrader & Frechtte (1985), the task of risk analysis is to resolve the following problems of risk and to help us evaluate them.

- How safe is "safe enough" ?
- How much ought we to pay for safety?
- How equitably ought we to distribute societal risks?
- How reliable are our scientific measures of risk?

Answering these questions means making a selection among alternatives. Thus, acceptable-risk problems are decision problems.

It is the basic right of every individual to live in a healthy environment. Civilization makes life more comfortable but it has created environmental imbalances. From our past experience we learn that Man has the capability of modifying his environment according to his needs and requirements. This knowledge has helped us to both pollute environments and to also reduce risks as well. Success in risk perception depends upon the subject being able to perceive and to act to change or modify the risk or to displace it.

The perception of risk is central to the concern which the public frequently associates with proposed hazardous waste treatment, storage and disposal facilities (TSDF). In recent years rapid development of medical waste and the risk of disposal technologies has been accompanied by the potential to cause catastrophe and damage to the environment and life forms that reside in it. The concept of perception appears in many hazard pollution studies but with little consistency of use. Recent risk perception studies include:-
Assessment of risk made by potential victims, risk levels and attitudes to the environment (Malhotra, 1979), the identification of hazards (Jackson, 1981) and the awareness of physical processes contributing to them (Eastwood, 1981) as well as comprehension of the character of hostile environments (Chang, 1978). A better understanding on the part of disposal facility proponents of how the public

perceives risks may facilitate the better locating of hazardous waste, treatment, storage and disposal facilities (TSDFs) (Nehnevajsa, 1984). Mileti (1975) believes that people are capable of perceiving the adverse effects of an occurrence and, when considering risk, of balancing these against the benefits arising from a possible development. Risk perception is in turn viewed as a function of seven other variables. (Fig 4.4.1) In Mileti's words:

" Despite faults in human cognition of risk, the probability of risk-mitigating adjustment increases as a positive function of risk perception through the mediating effect that perceived risk has on the variables of image of damage and perceived benefits of such adjustment ... Image of damage is what social units think will happen to themselves, possessions and community were an environmental extreme to occur; it has a positive effect on both perceived benefits of risk-mitigation policy and on risk-mitigation adjustment. The more potential damage imputed on the basis of risk, the more likely a social unit will adjust to that risk. Perceived benefits, positively affect the probability of risk-mitigating adjustment to the extent that anticipated benefits are worth the costs of policy implementation" (Mileti, 1975).

Mileti's model is largely based on work carried out in the past few decades. Many studies, largely within psychology, have concentrated on the perception of the probability aspect of risks (Kahnman, et al., 1982; Nisbeltt and Ross 1980). These researches have provided an insight into our ability to estimate probabilities.

Perception of risk includes three components; awareness, knowledge and value. Awareness is largely a function of time and publicity. Knowledge and values are related to social and demographic variables such as age,

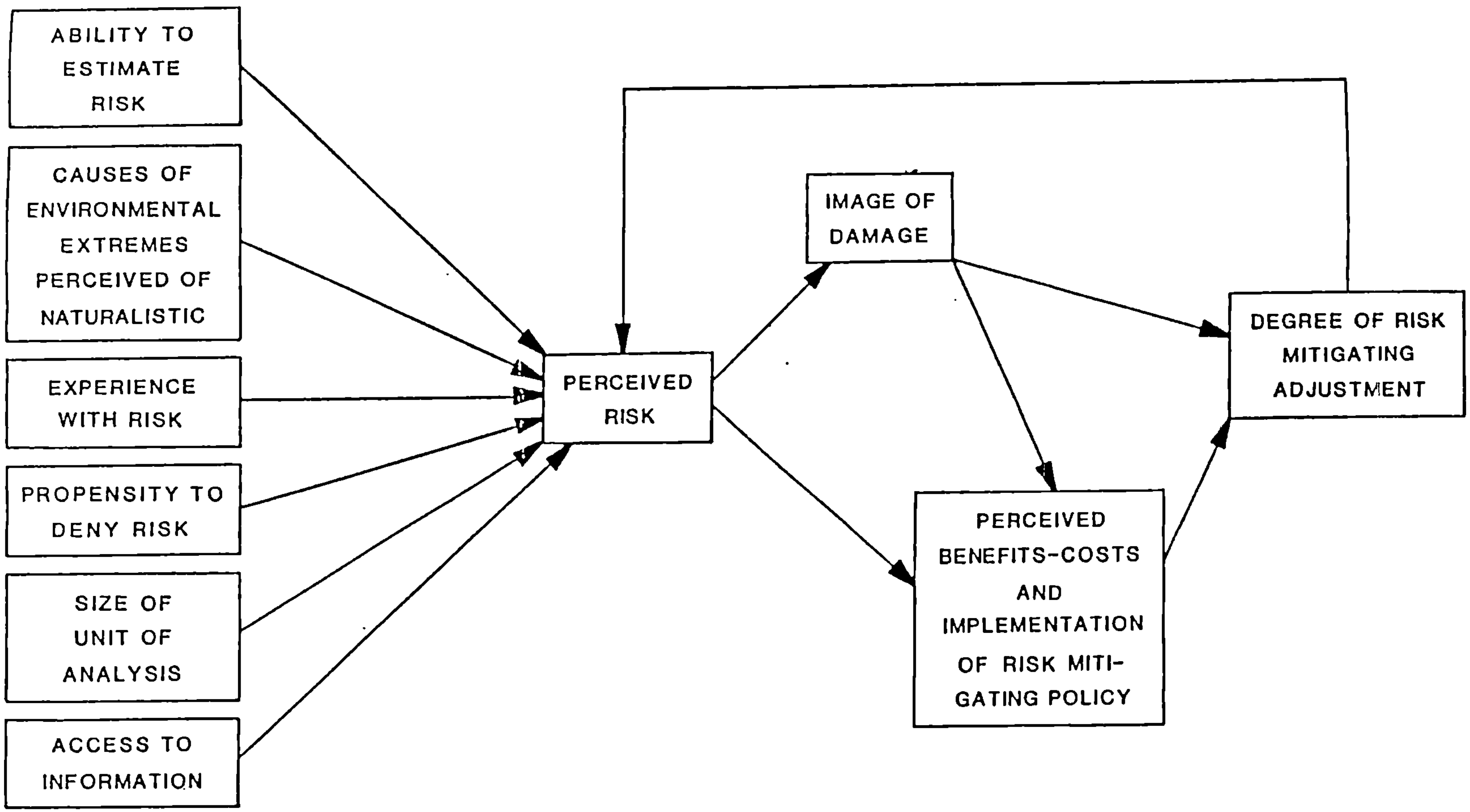


Figure: 4.4.1

Causes and Consequences of Risk Perception

Source: Mitchell, 1984

sex and education level. Awareness of a risk can be nothing more than having heard the name, or understanding that it exists. It does not show any degree of knowing nor even minimal information about the problem (Whyte, 1982). For instance, in 1980, in Canada a survey showed that while 65% of respondents had heard of acid rain (many of whom were also prepared to say that it was the number one environmental problem in Canada) only 10% could correctly say that it was associated with sulphur dioxide or nitrogen dioxide pollution (Whyte and Burton, 1982). However, awareness of a risk seems to be widely a function of publicity and time. It is necessary to understand the dynamics of risk perception and three approach are as follows:-

1- Long-term monitoring of public risk perception;
2- Public education in risk assessment;
3- Establishing a process for integrating scientific risk estimates with public risk perceptions (Whyte, 1982).

4.5 Risk assessment

Risk assessment is a relatively new technique which had its beginnings in the mid 1960s. There are several theoretical problems associated with risk assessment techniques which may be attributable simply to the relatively recent development of this discipline. The term "risk assessment" is used to explain the total process of risk analysis, which includes both the determination of level of risk and social evaluation of risks. Determination includes both identifying risks and estimating the possibility and magnitude of their occurrence. Risk evaluation measures both risk acceptance, or acceptable levels of societal risk and risk aversion, or methods of avoiding risk, i.e. alternatives to involuntarily imposed risks (Rowe,1980). Figure 4.5.1 shows the relationship between the various aspects of risk assessment.

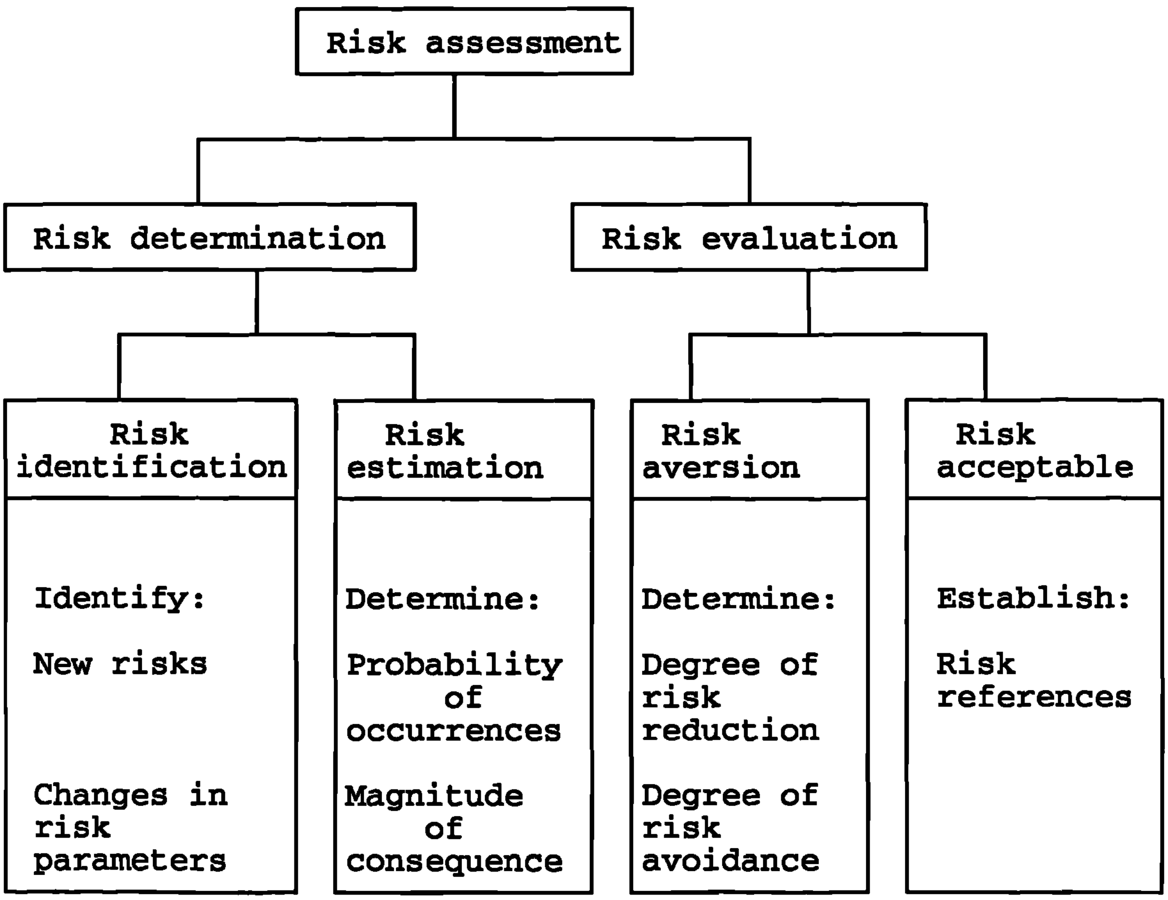


Figure 4.5.1 The module of risk assessment

Source: Rowe, 1980.

There are various ways in which risk assessments are accomplished in different countries. For instance, about four times as many drugs have been approved for physicians' use in Britain as in the United States of America, over the last decade (Kates, 1978). This difference is explicable in part on the basis of variations in risk assessment strategies in the two countries. For example in assessing risk to human health it is necessary to consider:-

1. The nature of risk and the potential health hazard to human or other species;
2. The techniques and models to be employed for estimating the risk at low doses of material that are believed to have genotoxic, epigenetic or carcinogenic action.
3. The validity of research methods to avoid excessively optimistic forecasts.
4. How numerical values should be presented.
5. How to employ the notion of acceptable risk.
6. The criteria for selecting chemicals for priority action (since more than 100,000 industrial chemicals are in use, it is essential that a balanced scientific view be taken).
7. The suppositions that are made regarding human exposure to compounds in drinking water, soil, air, food and exposure from other possible routes.

8. The significance which must be accorded to material containing reproductive, immunotoxic and behaviour'al toxicity (Gow, 1988).

There are many models for risk assessment and risk management. In the last decade, formal models have been developed by the Royal Society in the UK (Royal Society, 1983), the National Research Council in the USA, (National Research Council, 1983), the Interdepartmental Working Group on Risk-Benefit Analysis in Canada (Interdepartmental Working Group on Risk-Benefit Analysis, 1989) and the World Health Organization (1985a). These models are used to illustrate the important elements of risk management and risk assessment and have many similarities. Figure 4.5.2 illustrates the model developed by the Interdepartmental Working Group on Risk Benefit Analysis. A broad range of risk analyses have been carried out, some of which are scientific and quantitative, a second group which are qualitative and a third group which study the management of risks.

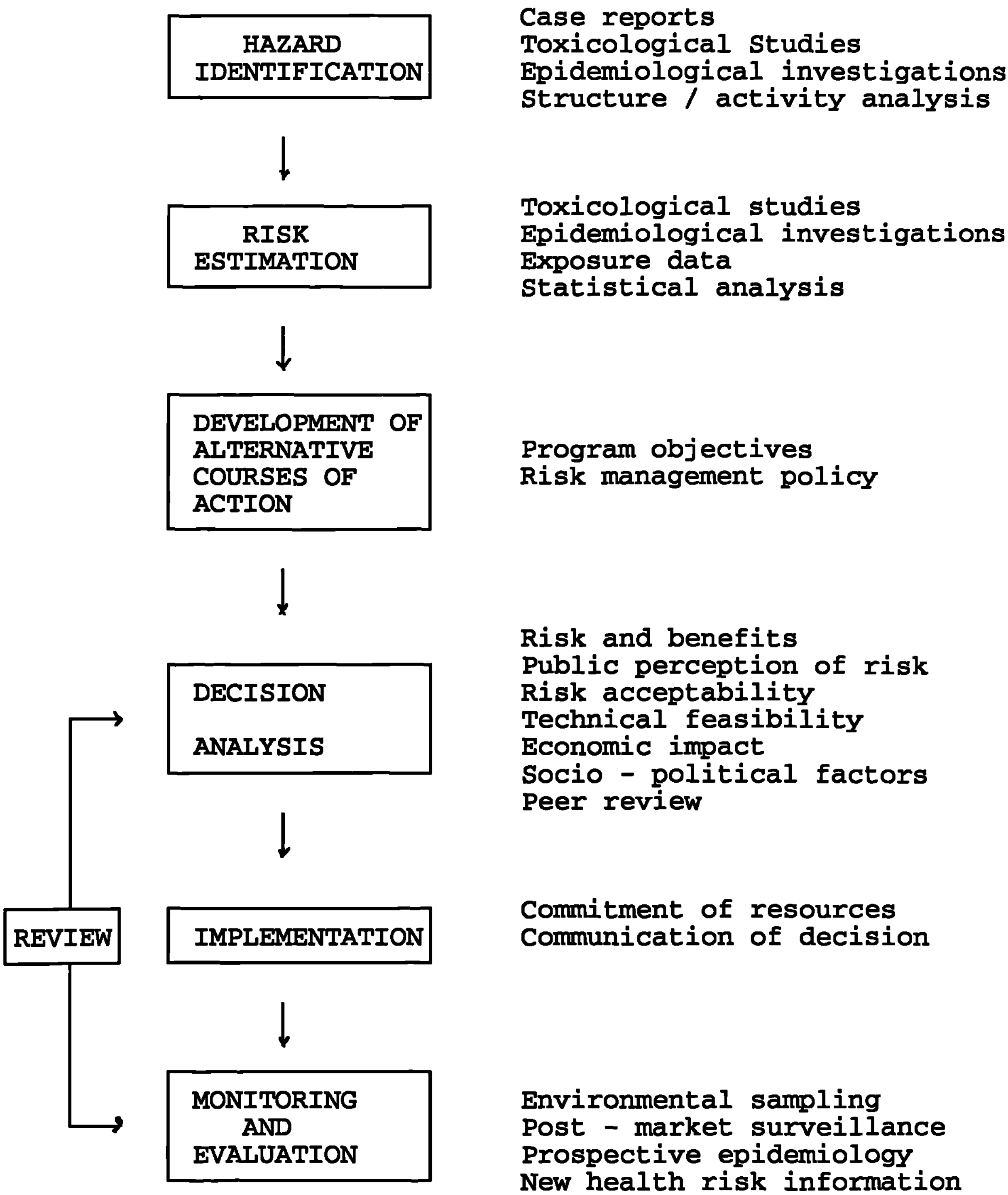


FIGURE 4.5.2 The process of Risk Assessment and Risk Management
Source: Krewski, 1987.

Although there are differences in the ways in which risk assessment is accomplished in different countries, they usually contain three steps; risk identification, risk estimation and risk evaluation.

4.5.1 Risk identification

Risk identification is achieved by means of different scientific methods, particularly those common in toxicology and epidemiology, and the conclusions are dependent upon the employment of a number of biostatistical techniques (Shrader, 1985; Gratt, 1987).

4.5.2 Risk estimation

The second step of risk assessment is risk estimation; it is measurement of the range of potential consequences of a hazard (Otway and Pahner, 1976). Examples of risk estimation techniques include subjective and objective measurements from personal judgment, models and formulae.

4.5.3 Risk Evaluation

The third step of risk assessment is risk evaluation. It is the process of determining the meaning or value of the estimated risk to those individuals affected by the hazard (Otway and Pahner, 1976).

The Royal Society (1983), have defined risk evaluation as the complex process of determining the significance or value of the identified hazards and estimated risks to those concerned with or affected by the decision. It therefore includes the study of risk perception and the balance between perceived risks and perceived benefits (Royal Society, 1983).

Generally, there are two categories of methods used in evaluating the acceptability of risk; the formal and informal methods. This is the most important of all informal approaches to risk evaluation. In the formal methods of risk evaluation we can rationally arrive at decisions about acceptable risk even in a short period of time. But the informal methods are based on the presumption that risk cannot be analyzed adequately in any short period of time (Shrader, 1985). The formal method is called risk-cost-benefit analysis. The informal methods include revealed preferences, natural standards and expressed preferences. These are shown below:-

a. Risk-cost-benefit analysis.

This method is a formal one and is well known to practitioners of welfare economics. Risk - Cost - Benefit analysis and decision analysis are the most outstanding formal methods of evaluating acceptable risk. Formal methods attempt to clarify the issues involved in evaluating the acceptability of risks through the application of well defined principles of reasoning (Shrader, 1985).

The majority of the literature available related to the disposal of solid waste has been directed at achieving a balance between the costs and the risks of disposal of solid waste. Figure 4.5.3 shows what it is that humans are trying to achieve and what they are trying to avoid. According to Wilson (1982) in the search for alternative techniques, attention is now focused on the general issue of project evaluation, that is on methods of comparing one way of operation with another. In general terms any method can be divided into four necessary steps:-

1. List the alternative options.
2. List the assessment criteria to be used.
3. Measure the implementation of each option against each criterion.
4. Assess which is the preferred alternative.

List the options and the assessment criteria. It is useful to arrange the information in a "decision matrix" table. Table 4.5.1 illustrates a decision matrix for municipal waste management. This diagram is a simplified version of one used by Wilson for presentional purposes.

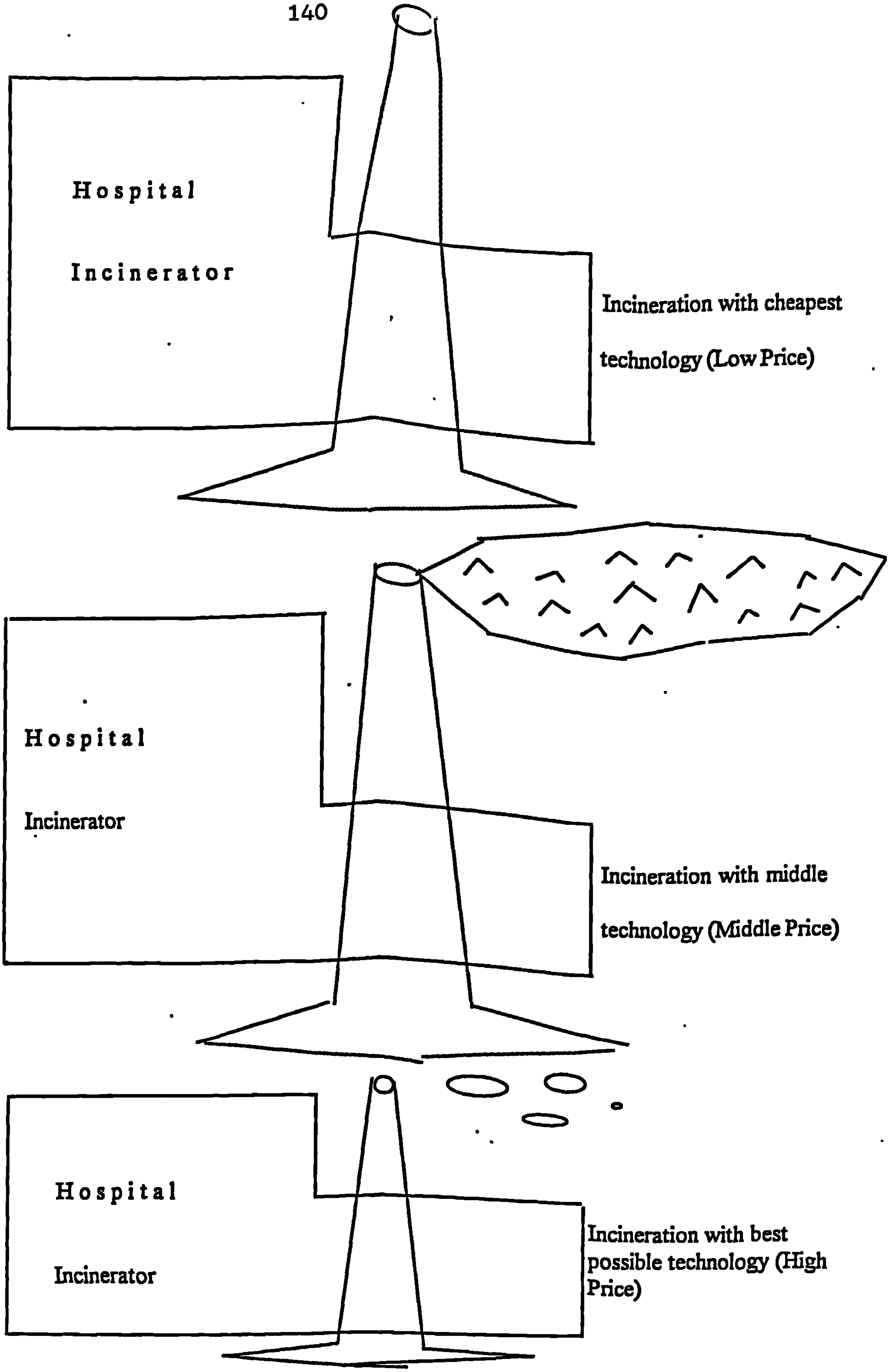


Figure 4.5.3
The relationship between adapted incineration technology and environment.

Table 4.5.1 Decision matrix for municipal waste management

Options Criteria	Landfill	Transfer/ Landfill	Incineration	RDF *
Cost/tonne	1	2	4	3
Capital cost	1	2	4	3
Variability of market	1	1	3	4
Technical adequacy	1	1	3	4
Volume reduction	4	4	1	2
products	?	?	?	?
Efficiency of recovery	4	4	2	1
Traffic	4	3	1	1
Air pollution	2	2	4	1
Water pollution	4	4	1	2
Public health	4	4	1	2
Aesthetics	4	3	2	1
Public acceptance	4	3	2	1

Source: Wilson, 1982.

Although, there are approximately thirty options for municipal waste management (the majority of which are described in Chapter Three) only four methods are presented here, whilst the criteria are divided into thirteen out of perhaps fifty possibilities. The criteria are broadly grouped into five categories, these being, economic, resources, conservation, environmental and political aspects. Some qualitative and quantitative assessments have been chosen for the first three groups which are illustrated in Table 4.5.2. Unfortunately the lack of information in the table for environmental and political criteria does mean that such assessments are not feasible.

b. The method of revealed preferences.

This approach is an informal one. This method assumes that, through trial and error, society has arrived at a near optimal and acceptable balance between the risks and benefits associated with any activity. This approach uses the level of risk that has been tolerated in the past as a basis for evaluating the acceptability of present risks (Shrader, 1985; Smith, 1992).

c. The method of natural standards.

This method is an informal one. It combines approaches such as Risk-Cost-Benefit Analysis and the method of revealed

Table 4.5.2 Example of a decision matrix

Options / Criteria	Landfill	Transfer/ Landfill	Incineration	RDF *
Cost/tonne	£4	£10	£20	£12
Capital cost	£1M	£2M	£8M	£4M
Variability of market	Zero	Zero	Moderate	High
Technical adequacy	Proven	Proven	Some problem	New
Volume reduction	0	0	80%	60%
Products	Land (gas)	Land (gas)	Steam Fe	RDF Fe
Efficiency of recovery **	0	0	50%	70%
Traffic Air pollution Water pollution Public health Aesthetics				
Public acceptance				

* RDF : Refuse Derived Fuel

** Municipal Waste Disposal

Source: Wilson, 1982.

preferences. The practitioner of this method infers values indirectly, by asking people, directly, what risks they deem acceptable (Fischhoff, et al., 1979). Results of this method indicate that subjects believe that more beneficial activities may be allowed despite higher levels of risk associated with them. They also show that society has a double standard of acceptability for certain hazardous events.

d. The method of expressed preferences.

This is an informal method. It consists of asking a sample of the community to express its preferences and then considering the resulting information. The preferences exposed in the sample are used to assess the importance of different characteristics of risks and to rate subjects' perceptions of the risks and benefits accruing to society from different activities possibilities and technologies. The greatest defect in the method of expressed preferences comes from the limitations of the group expressing its preferences. The best way to overcome this difficulty is to have a standard for safety which is independent of the beliefs of a specific part of society (Shrader, 1985).

Otway (1973) reported the significance of risk evaluation in the overall process of risk assessment, especially in assessing society's response to a new technology or new decision. Society's attitude to risk is determined by a mix of psychological functions such as perception, conditioning and learning. He described three methods for discovering and inferring public attitude as follows:-

i. Utility Theory.

According to Otway (1977) utility theory has been helpful for assessing the expectation of decision-makers, that is their expectations of the "social utility" to be gained from a special decision as a function of technical variables. The application of utility theory to risk evaluation is comparatively limited.

ii. The use of statistical data arising from research into social psychology.

This method is that of subjecting estimates of individual risk to societal evaluation of risk. Otway (1977) expresses the opinion that this method is not totally satisfactory since each value of individual risk is characterised by many variables other than statistical estimates of frequency of occurrence.

iii. Attitude Theory.

Attitude can be best defined as an organized structure of ideas with both affective and cognitive components, which results in some reaction (Fishbein & Ajzen 1975). According to Otway (1977) Attitude Theory is an applicable and helpful tool in risk evaluation. The definition of "attitude" makes it a useful predictor of the totality of behaviour towards the "attitude object".

According to the theory a person's attitude toward an object is a function of his beliefs about the object and the evaluative responses associated with those beliefs about the object. His attitude toward the object can be described as:-

$$A_o = \Sigma^n{}_b \ b_i \ e_i$$

Where:- A_o = Person's attitude toward to object o

b_i = The strength of i about object o, for example the subjective probability that o is related to attribute i.

e_i = evaluation of attribute i.

n = number of beliefs.

Individual responses may then be collected to obtain a value for the total expected social response of a given social group.

4.6 Risk from hospital waste incineration

In terms of air pollution there are three types of emission from incineration; continuous, upset and accidental. Only continuous emissions (the most widespread) are discussed here. Continuous emissions of potentially damaging material can happen during normal operation of an incineration facility and can result in chronic environmental and health effects. These can happen by emission from the incinerator stack and from fugitive emissions which may happen during the handling, storage and treatment of waste. (Adverse impacts are also possible from ash and other residues).

There are three steps in the process of estimating the risk of emissions from hospital waste incineration.

a. Estimating or measuring emissions from the stack or other source at the facility.
b. Determining the pathways by which the emissions reach humans and the environment (see Chapter 9).
c. Determining the impact on the environment.

The results of the application of accepted risk/hazard /impact analysis techniques have been reported by Weinberger et al., 1984; Edward et al., 1985. These techniques contain three levels; estimating the amount of substance escaping from the source, analysis of the action of the toxins from the source to a potential point of exposure and estimating the toxicity of the compounds once a human or environment is reached (EPA, 1988c).

Any of the formal or informal methods can be used in evaluating the risk associated with hospital waste incineration. The risk of accidents from hazardous waste is discussed below.

4.6.1. Accident risk assessment

Awareness of the risks and consequences of environmental releases of hazardous waste, especially hospital waste and hospital incinerator effluent discharge has increased in the wake of the Bhopal and Chernobyl incidents. Hospital incinerators, particularly those located close to residential areas, now cause public concern because of the potential risks and liabilities involved and the way in which they are perceived by the individuals concerned.

The public now often requires that steps be taken to prevent or at least to reduce losses from potential releases of hazardous material into the environment. An accident risk evaluation is a technique for assessing impacts of such release. It could help sensitize all concerned parties to what could occur and more importantly, identify the mitigation measures needed to reduce risks to public health and property.

Although accidents that have occurred at incinerators are not well documented, the risks associated with incinerating hospital wastes conservatively range from 1×10^{-6} to 1×10^{-8}. This concept means that the risk of an individual, who lives in the neighbourhood of an incinerator, incurring a health effect ranges from 1 in one million (1,000,000) to one in one hundred million (100,000,000). Incineration seems to be less risky than other waste disposal methods. The risks associated with hazardous waste incineration are 1×10^{-5} to 1×10^{-8} for industrial furnaces, and for boilers the associated risks range from 1×10^{-5} to 1×10^{-7}. (American Society of Mechanical Engineering, 1988).

Many researchers have reported that the risk of incineration to human health is low (Albert, 1983; Trenholm et al., 1984; Edward et al.,1985; Curtis et al., 1987; Oppelt, 1987; Lewtas, et al.,1987).

4.6.2. Chemical risk assessment

Chemical risk assessment is a tool for estimating the risk that a specific material poses. There are generally four steps to a chemical risk assessment:-

a. Hazard Identification

The identification of a particular hazard through the use of a battery of toxicological tests represents only the first step in the risk assessment process. Hazard identification is independent of how much of the material is involved or whether any living thing is likely to be exposed to it (Burke, 1984).

b. Dose-Response Analysis

This looks at the risks posed by the material at various levels of exposure. For example, saccharin and dioxin cause cancer in animals but saccharin takes millions more times the concentration than dioxin to produce equivalent effects in laboratory testing (Burke, 1984). The majority of literature available relating to the disposal of waste has been directed at achieving a balance between the costs and the risks of disposal of solid waste.

c. Exposure Assessment

Exposure Assessment is the estimation of the nature of exposure, of how many people it affects and the time span in which this exposure may occur. For many materials, exposure analysis involves complete populations of consumers or other individuals who may have been exposed to the site over several years. A shorter time focus involves the maximum level of exposure of people living near to a specific source, for example a hospital incinerator, for a shorter period (Burke, 1984).

d. Estimation of Risk

Once a material has been positively identified as a serious hazard, epidemiological and toxicological trials are carried out on it in order to estimate the magnitude of the risk.

4.7 Problems in Risk Analysis

Dilemmas in understanding probabilistic processes, misleading personal experiences, the anxieties produced by life's gambles and biased media coverage, frequently lead individuals to deny uncertainty, maintain unwarranted confidence in judgments of fact and misjudge risk (Slovic, 1982).

Covello (1983) reported that studies of risk perception have often been based on small biased samples. Inaccurate measurements of distances from a hazard and the repetition of contact have not always been considered. Furthermore, organizational impacts and social structural variables such as sex, age, education, income, marital status, occupation, ethnic origin, religion and organizational membership have seldom been adequately connected to perceptions of risk (Covello, 1983; Regens, et al., 1983).

The deficiency of statistical data and the lack of clear standards that risk assessments must meet to use as testimony in policy decisions has meant that there have been few guidelines for undertaking risk analyses (US Nuclear Regulatory Commission, 1975). Because of these limitations in the availability of standards and data, the practice of risk assessment is only a developing science (Kates, 1978).

Surveys of risk perception also often have too many prejudices and biases. Respondents may be unfamiliar with the subject being measured and misunderstand the scientific issues being studied and so give substandard responses (Covello, 1983; Dillman, 1978). Many specialists maintain that people magnify some risks, and minimise others. For instance in relation to hospital waste they may minimise the risk of things such as fly ash in their homes (Johnson & Luken, 1987; Sandman et al,1987).

In researching risk perception, peoples' reactions to different kinds of risks are measured (Sjoberg, 1987; Rogers and Bates, 1983; Schwing and Albers, 1980). Even so risk perception with regards to incineration hazards to human health is still incompletely understood. The problems are not so much in understanding probabilistic processes or the factors that affect perceived risk but more in accounting for the differences in perception because of different levels of understanding and the influences of biased media coverage (Slovic, 1987., and Otway and Pahner, 1976).

At first sight, assessing the human risk perceptions would seem to be very easy. Just ask a question like, "Do you think that an incinerator in the vicinity of your house would be a problem for you?" or "Do you know anything about the effects of emissions from an incinerator's chimney upon children's health? " or " Do you feel concerned about living in the vicinity of a hospital incinerator?". But risk perception is a subjective process by which persons intuitively assess risk. Because of human conditioning and limitations in knowledge processing, the public sometimes misjudges risk and accepts views which can be at odds with objective estimates. However, decision makers must be informed of public perception of the risk associated with different hazards, and give these views proper analysis in selecting a suitable risk management strategy.

CHAPTER FIVE

ENVIRONMENTAL IMPACT ASSESSMENT

5.1 Introduction

In the previous chapter comments were made on risk assessment relating to waste and hospital solid waste disposal and its treatment. In this chapter, Environmental Impact Assessment (EIA) will be discussed and particular attention will be given to the possible use of the technique in relation to the siting of hospital waste incinerators. The section begins with a review of the history and different definitions of EIA, its advantages and disadvantages. The section then moves on to consider the use of EIA in the UK in general and its relevance to hospital solid waste incineration in particular.

During the 1950s and 1960s environmental awareness increased and was centred on the environmental consequences of economic development. In developed countries this concern grew particularly in connection with the unforeseen environmental consequences of development projects. Prior to 1970 the traditional method of control, in the United States of America, over projects which were seen as possibly damaging to the environment was through direct legal action. Some twenty years ago, the United States passed the National Environmental Policy Act which demanded that federal authorities consider the environment before authorizing major developments (Canter, 1977; Munn, 1979; Clark et al., 1980; Bisset, 1980; Wathern, 1988).

5.2 General discussion

In recent years, in developing countries also, increasing attention has been focused on the efforts made to construct a coherent and systematic procedure to appraise the effect of major industrial projects on the environment and its embodiment within the development process. In 1969 Environmental Impact Assessment (EIA) was required by the *National Environmental Policy Act in the* USA. For the first time, from the 1st January 1970, a direct method of project control occurred. This act required the production of environmental impact statements for major federal development projects. Such documents must be designed to produce statements on:-

a. The environmental impact of the suggested action.
b. The adverse environmental effects which cannot be avoided should the suggested plan be implemented.
c. Alternatives to the suggested action.
d. The relationship between the short term uses of Man's environment and the maintenance and enforcement of long term productivity.
e. Any irretrievable and irreversible commitments of resources which would be involved in the suggested action should it be implemented.

The Act gave responsibility for producing guidelines for the preparation of environmental impact statements to the Council for Environmental Quality and the agencies carrying out the review and assessment processes. In the USA Environmental Impact Statements have to address the eight points listed below:-

1. A description of the proposed action including its purposes, project area, resources involved, the physical changes proposed and ecological systems to be changed.

2. A description of alternatives to the proposed action and a description of their impacts. Contained there in should be an evaluation of the "no go" alternative.

3. A study of the relationship of the proposed action to existing land use plans, policies and controls in the affected areas.

4. A description of any probable adverse environmental effects which cannot be avoided, including physical, social and aesthetic impacts.

5. An investigation of probable impact of the proposed action on the environment, containing both positive and negative effects.

6. A debate on the relationship between long term and short term uses of land and the maintenance or enhancement of its productivity.

7. An evaluation and description of any irretrievable or irreversible uses of resources which would result from the development.

8. A demonstration of the other interests and considerations of Federal policy which may offset the adverse environmental side effects.

In the United States system two types of EIS are produced, a draft EIS and a final EIS. The draft EIS represents a summary of the environmental study in which (in the Federal System) the five items of National Environmental Policy Act outlined above must be addressed. The introduction of the United States National Environmental Policy Act stimulated research into a more formal and standardised approach to the presentation and review of the environmental impacts of new projects in other countries. Various types of EIA systems have since been adopted in Canada, Australia, Japan (Lee and Wood, 1980b; Harashina, 1988), Southeast Asia (Roque, 1985) and Czechoslovakia (Riha, 1988). Also in EEC member states, particular interest has been shown in France, West Germany, Ireland, and the Netherlands , in all of which certain EIA provisions have been made (Lee N.; Wood C., 1980a) and UK (see 5.7); Dobry (1975); Royal Commission on Environmental Pollution (1976); Clark et al. (1976); Catlow and Thirlwell (1977); Turnbull (1981); Hancock, (1991).

EEC Directive 85/337 was on the assessment of the effects of certain public and private projects on the environment. The Directive came into force in Member States of the EEC on 3 July 1988 (CEC, 1985). This Directive places a compulsion on member states of the EEC to carry out assessments for proposed developments which are likely to have significant impacts on the environment caused by their size, nature or location. Assessment will be carried out by developers who must produce a list of information to the competent authorities who will be making a decision on whether or not to give a development permit. The impacts of a project on the environment should be assessed to take account of concerns to protect human health, to contribute by means of an improved environment to the quality of life, to ensure the conservation of different species and to maintain the reproductive capacity of the ecosystem as a basic resource for life (CEC, 1985). Haigh (1987) has summarised the important requirements of the Directive as follows :-

a. An assessment is to be made of the significant impacts of certain development projects on the environment before planning consent is granted.

b. In co-operation with the planning authority, the developer is to produce certain information on the possible environmental impacts of a project and where required should outline the main alternatives discussed.

c. The public, those authorities with specific environmental responsibilities and other member states of the EEC should be consulted in advance and their views discussed.

d. The meaning of the decision taken by the authorities and any conditions attached to the development consent must be made public (Haigh, 1987).

5.3 Definitions of EIA

No general and universally agreed definition of EIA exists as the concept is continually growing and changing. Since 1969 various documents have described not only definitions and terms, but regulations and many methods for the assessment of environmental impacts for instance, Leopold et al., 1971 ; Ditton and Goodle, 1972; Burchell and Listokin, 1975; Corwin et al., 1975; Lee, 1983; Munn, 1979; Graybill, 1985; Canter, 1986. The following examples, however, give the more common definitions:-

According to Munn (1979)," EIA is an activity designed to identify and predict the impact on the biogeophysical environment and on Man's health and well-being of legislative proposals, policies, programmes, projects and operational procedures, and to interpret and communicate information about the impacts". Heer and Hagerty (1977) believe that EIA is based on the prediction of the changes in environmental quality which would result from the proposed operation; "...assessment consists in establishing quantitative values for selected parameters which indicate the quality of the environment before, during and after the action."

The Battelle Institute (1978) defined Environmental Impact Assessment thus, "EIA is an assessment of all relevant environmental and resulting social effects which would result from a project". The Ministry of Health and Environmental Protection stated that EIA should not be regarded as a cure-all for the defects in present planning and decision-making or as a means that guarantees decisions beneficial to the environment (MHEP, 1980).

EIA compares a variety of alternatives by which a proposed objective may be realized and seeks to identify the one which represents the best combination of economic and environmental costs and benefits; "To identify, predict and to describe in appropriate terms the benefits and penalties of a proposed development. To be useful, the assessment needs to be communicated in terms understandable by the community and decision maker and the pros and cons should be identified on the basis of criteria relevant to the countries affected" (United Nations Environment Programme, 1979).

According to Ahmad and Sammy (1985) EIA attempts to weigh environmental effects on a general basis against economic costs and benefits in the overall project evaluation. It is a decision-making tool and they believes EIA is a study of the effects of a proposed action on the environment. In this context, environment is taken to include all aspects of the natural and human environment.

According to Biswas and Geping (1987) Environmental Impact Assessment comprises the steps of identification, predication, and evaluation. Many different terms may be employed to define these activities. The majority of these are as follows:-

a. Environmental Assessment (EA)
b. Environmental Appraisal (EA)
c. Environmental Impact Assessment (EIA)
d. Environmental Impact Appraisal (EIA)
e. Environmental Impact Analysis (EIA)
f. Environmental Impact Evaluation (EIE)
g. Environmental Identification (EI)
h. Environmental Inventory (EI)
i. Environmental Baseline Study (EBS)
j. Ecological Reconnaissance (ER0)
k. Environmental Setting (ES)
l. Initial Environmental Examination (IEE)

The definition of terms is essential in that it provides for understanding of what has become a confused area of knowledge. It is self-evident that much of the present confusion that surrounds EIA emanates from the lack of a series of precise definitions of the terms which have been used. Although Environmental Impact Evaluation, Environmental Analysis, Environmental Impact Analysis, Environmental Impact Appraisal Environmental Appraisal, Environmental Impact Assessment and Environmental Assessment are generally used for the same purpose, Biswas suggests that in future the terms Environmental Impact Assessment (EIA), Environmental Impact Statement (EIS) and Environmental Impact Analysis (EIA) should be used with precision, and that any alternative titles should be related to these terms.

Before leaving this section on "definition" of EIA, it is necessary to draw a clear distinction between the Environmental Impact Assessment (EIA) and Environmental Impact Statement (EIS). These terms have been used interchangeably by many authors, but they do not represent the same thing (Ahmad and Sammy, 1985). An Environmental Impact Statement for a proposed project is a summary of the findings of a detailed environmental review process. Burchell and Listokin define an EIS:
"The actual presentation that results from an environmental impact analysis. It may be in the form of text, statistics, matrices, overlays, film, computer graphics and other graphic techniques, or a combinations of any or all of these, depending upon the client and the nature of the

development project" (Burchell, 1975).

The terms EIA and EIS both have their origin in the National Environmental Policy Act (NEPA) and the Council on Environmental Quality Regulation in the USA. According to Bisset (1987) "EIA is concerned, basically, with identifying and assessing the environmental consequences of development projects, plans, programmes and policies in an attempt to ensure that the 'best' alternative for development is selected. The results of EIAs are usually presented in documents or reports known as Environmental Impact Statements 'EISs' [illegible], [illegible]. Briefly, EIS describes the fundamental activity, and EIA is simply an introduction to it.

In summary, Environmental Impact Assessment is a tool or a method whereby the affects of a proposed action on the environment can be identified and evaluated. It contains:-

a. A description of the proposed development. This was reported by Catlow and Thirlwell, 1977 and Ortolano, 1984.
b. Identification of the area of the project (Clark et al. 1981).
c. Predication of the magnitude of the impact of various actions on the environment (Wathern, 1988; Environmental Resource Ltd., 1984).
d. Evaluation of the significance of the effects of

alternative actions on the environment (Clark et al., 1981).

e. Communication of impact information to users such as decision-makers and the public (Erickson, 1979; Ahmad and Sammy, 1985).

5.4 Steps in the EIA process

Environmental Impact Assessment aims at the best decision-making. It is often agreed that EIA should be concerned with the identification, measurement, interpretation and communication of environmental impacts of the suggested action. Attempts should be made to decrease potential adverse effects and increase likely benefits through the identification and assessment of alternative sites and/or processes (Clark et al.,1984). The EIA process, explained by the Commission of the European Communities in European directive (1985), generally contains the following characteristics :-

a. Deciding if an EIA is needed;

b. Determining the coverage of an EIA;

c. Preparation of a draft EIA;

d. Reviewing the environmental statement;

e. Consultation and public participation;

f. Preparation of a final environmental statement incorporating the findings from consultation and public participation;

g. Reaching a decision;

i. Monitoring and post-auditing (CEC, 1985).

There are many ways to establish an EIA, differing from country to country. Ahmad and Sammy (1985) described the steps in an EIA thought to be suitably practical and potentially cost useful for adoption in developing countries (Figure 5.3.1).

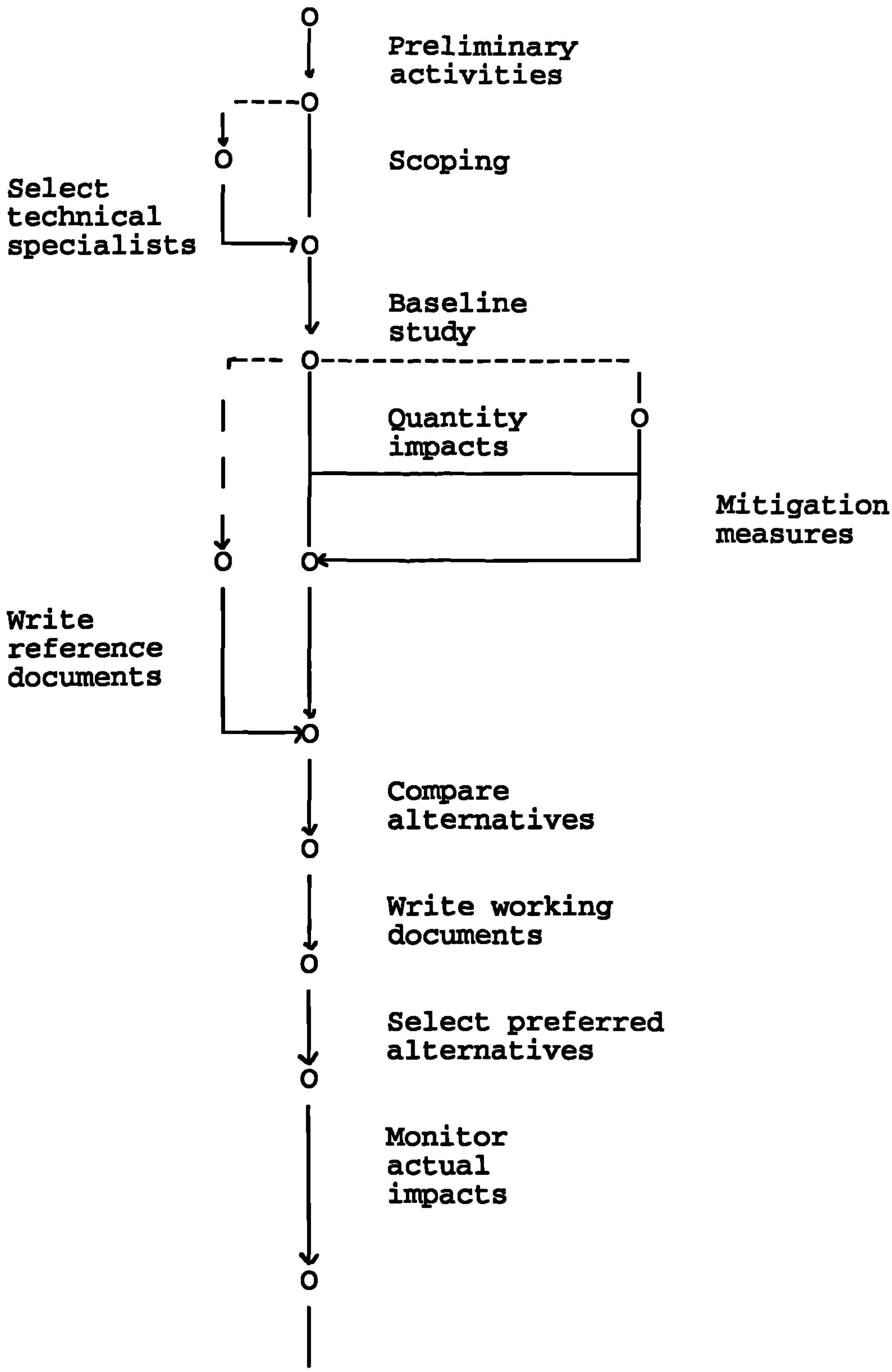
As the process of EIA has already been studied by several authors and organizations Canter, 1977; WHO, 1983; CEC, 1985; Ahmad and Sammy, 1985; Biswas and Geping, 1987; Wathern, 1988 it will be discussed here only briefly. The first step in the EIA process is "Preliminary Activities". According to Ahmad and Sammy (1985), there are many prerequisites that must be fulfilled for an appropriate EIA to be accomplished. These are as follows:-

a. Identify decision-maker(s);

b. Decide on work allocation;

c. Write description of proposed action;

d. Review existing legislation.



Note: —— Activity
----- Time delay

Figure 5.3.1 Activity diagram for EIA
Source : Ahmad and Sammy, 1985.

The Council on Environmental Quality (1980); Ahmad and Sammy (1985); and Beanlands (1988) reviewed Impact Identification or Scoping. According to them, scoping is a crucial step in the EIA process, as it can control cost and optimize the effectiveness of the assessment by the early identification of potentially serious dilemmas. It is the procedure used to determine the terms of reference. The process usually consists of two stages. First, a comprehensive list of all impacts is gathered using a number of different techniques, *including checklists*, metrics, guidelines and professional judgments. Secondly, this list is carefully examined and a manageable number of the important impacts are selected for study using four criteria : magnitude, extent, importance and special sensitivity. Magnitude concerns the scale of the impact, that is, the amount of change that will be experienced. Importance refers to the significance of the impact. The extent of an impact concerns the area which will be affected. Special sensitivity refers to the specific environmental concerns of some areas such as air pollution. The baseline study refers to the collection of background information on the environmental and socioeconomic setting of the proposed development project. It is a simple record of what existed in an area prior to any developmental action. A baseline study can be designed using the results of a scoping exercise.

There is little agreement on what measurement means in EIA literature. Generally it refers to a quantitative estimation of magnitude. Ahmad and Sammy (1985) state that the quantification of impacts is a very complicated and debatable technical aspect of an EIA. They suggest that perhaps it would be desirable to deal with controversy first, and the technical aspects later. The evaluation process usually referred to as impact quantification or predication begins after the project alternatives have been defined.

Mitigation measures refers to the need to determine the importance of an impact. It is not always possible to delete an adverse impact as a whole, but it may be possible to prevent or reduce its intensity by mitigation measures. As described by Ahmad and Sammy (1985) the Assessment stage consists of combining technical information, environmental losses and gains with economic costs and benefits, in order to produce a full picture for each project alternative. An appropriate tool of the economists for this step is cost-benefit analysis; it is discussed in Chapter 4.

Documentation refers to the presentation of information which helps decision-maker(s) and interested people come to some conclusions on the merits and demerits of a proposed project. The documents which will arise out of an EIA will fall into two sorts, reference documents which contain a detailed record of the work so far completed, and working documents which are a formal means of communication from the technologists to the decision-maker(s).

If Environmental Impact Assessment is to be effective it cannot be considered in isolation from other aspects of the planning process. In planning for development, all relevant factors such as economic, social, political and technical factors, have to be taken into account. This phase will not be described here in detail since it is fully described and discussed by Munn, 1979; Lee and Wood, 1978; Canter, 1977; United Nations Economic commission for Europe, 1979; Clark et al., 1984; Wathern, 1988.

Wathern (1988) reported that the objective of EIA is not to force decision makers to accept the minimum environmentally damaging alternative. The decision-making begins when the working document (which contains a list of project alternatives with comments on the environmental and economic impact of each alternative) reaches the decision-makers. A decision-maker can accept one of the project alternatives or ask for more study or refuse the proposed action altogether.

The term 'audit' does not have a clearly defined meaning in environmental science literature. Increasingly the term is used to explain the process of comparing the predicted environmental effects in an EIA with those which actually happen after implementation in order to assess whether the impact prediction process performs satisfactorily (Environmental Protection Agency, 1980; Bisset, 1984; Institute for Environmental Studies, 1977; Tomlinson, 1987). These authors and organizations state that EIAs based on predictions and post audits have shown how close those predictions were to actuality.

5.5 The Advantages and disadvantages or problems of EIA

In developed countries, opposition between local and any other interests in relation to a development proposal is a common problem. This dilemma cannot be resolved by EIA but it can help to clarify the issues at stake, before a decision is taken usually on the basis of political factors. EIA identifies, predicts and aids discussion of individual impacts and how they effect special environmental components and impacts on a human population (Clark, et al.,1984).

One of the greatest criticisms which has been directed at EIA is that it causes considerable expense and delays. In developing countries some people state that 'EIA is just another bureaucratic stumbling-block in the path of development' or 'EIA is a sinister means by which developed countries intend to keep the developing countries from escaping poverty'. But really EIA is not anti-development, EIA is a tool for development planning very similar to economic analysis. There have been many studies relating to the usefulness or otherwise of EIA as a tool for development planning and implementation control. It is thus useful to focus on some of the pros and cons of its introduction (Dean and Graham, 1978; Miller and Wood, 1983; Clark et al.,1984; Ahmad and Sammy, 1985; Wathern, 1988).

a. The Advantages of EIA

According to Lee and Wood (1978), who studied EIA systems in the United States and also in Britain and elsewhere, certain advantages may derive from its introduction and widespread use. The principal points of a EIA are designed to meet two basic requirements.

i. It should generate a systematic assessment of likely environmental impacts in a form suitable to the activity to which it relates.

ii. It should help decision making by integration into the planning process an early stage.

Lee and Wood reported that additional benefits which would result from provision for wider consultation are as follows:-

1. The nature of EIA is such that it involves specialists from a variety of fields in the examination and evaluation of the potential environmental consequences of a

development. It has been claimed that this enables better decisions to be made from an environmental point of view. (Lee and Wood, 1978).

2. EIA may engender greater and more informed public participation in the decision and planning processes relating to major developments which have a potentially significant affect on their own future environment (Lee and Wood, 1978).

3. The system may produce a more systematic and thorough assessment of environmental impact than would otherwise happen.

4. By presenting a significant element of external inspection, it may give greater assurance that environmental impacts will be assessed adequately and taken into account than would be achieved by purely internal administrative commitments by each agency (Lee and Wood, 1978).

b. The Disadvantages or problems of EIA

This section will briefly mention some of the problems encountered by the developing countries with EIA. It is clear that all problems associated with EIA could not be included. In many developing countries, the difficulties of introducing EIA originated from a deficiency of qualified persons together with a lack of any real understanding of the EIA procedure. Ahmad and Sammy (1985) summarized these problems in six categories as follows:-

- Too many alternatives;
- Too many impacts;
- Lack of data;
- Lack of expertise;
- Impacts cannot be quantified;
- Cost-benefit analysis is inappropriate.

Also a number of possible disadvantages have been studied by Canter, 1977; Clark et al., 1980; Lee and Wood, 1978; O'Riordan and Hay 1976; United Nations Economic Commission for Europe, 1979; such as the following:-

1. In some cases it has been claimed that the budget involved was so great as to cause the cancellation of certain projects.

2. It is sometimes thought that publishing details of a proposed development may, in certain cases, prejudice the developer's interests, particularly when this information relates to trade secrets.

3. It may also be argued that for certain impacts no satisfactory evaluation techniques have been developed. This means that in certain cases there may not be any satisfactory methods of weighing the environmental impact of a project against its economic impact.

4. It is thought that an EIA system may generate considerable delays which may unnecessarily hinder developments.

5. Concern has been expressed that any new decision making process may disrupt existing planning processes (Lee and Wood, 1978).

Lee and Wood claim that these problems are possibly less frightening than they at first appear. It is doubtful whether significant delay is inherent in an EIA system. Maximum time limits for each step in the EIA procedure can be created. Even in the United States case study investigations indicate that delays are more usually due to cumbersome administration and to deficiency or absence of co-ordination in decision-making rather than to the actual analysis of environmental impacts.

Another possible disadvantage is that in certain countries, and especially in America, the production of EIS has become a matter of routine, resulting in an effort to make the document "judge proof", and in the production of meticulously prepared but "lengthy and often dull documents" (Warner and Preston, 1974). In reply to this point, Garner (1979) has suggested that brief documents couched in appropriate language with a maximum length of 5000 words could replace the more voluminous documents which are frequently produced (Warner and Preston, 1974).

Fears that EIA may replace the present process could be reduced by incorporating the EIA approach within existing processes rather than establishing a parallel system.

5.6 Environmental Health Impact Assessment EHIA

Environmental Impact Assessment is becoming one the most effective tools in the planning of developments, whose possible environmental consequences are some of the main determinants of human health. For this reason the objective of reaching acceptable standards of health cannot be separated from that of achieving high environmental quality standards. Reports and publications are available to provide information on the relationships between environmental factors and human health such as the WHO 1979; Cohen, 1983; Robinson et al., 1983; Parke, 1983; Donaldson, 1984; WHO, 1983, 1985b; Go, 1987; Giroult, 1990.

The purpose of the Environmental Health Impact Assessment is to identify, a priori, the possible and likely environmental health consequences of a proposed action, so that negative impacts can be prevented or minimised by applying the best appropriate technology or, if this is not possible, by discussing alternatives to the proposed action which would prevent detrimental effects. The purpose of the system is not to avoid economic developments; actually, these are often a vital means for raising health standards. According to the WHO (1979) "

Environmental Health Assessment (EHIA) involves evaluating the benefits derived from the use of a particular product, and the costs associated with the use and disposal of chemicals. The evaluation of the benefits and the costs requires a multidisciplinary approach and the collaboration of environmental health experts of various kinds with technologists, ecologists and economists". A method for environmental health impact assessment is illustrated in Table 5.6.1.

Table 5.6.1 Processes of environmental health impact assessment.

Steps to be taken	Tools be used
Step 1 Assessment of primary impacts on environmental parameters	Regular EIA process
Step 2 Assessment of secondary or tertiary impacts on environmental parameters resulting from the primary ones	Regular EIA process
Step 3 Screening of impacted environmental parameters of recognized health significance (EH factors)	Epidemiological knowledge
Step 4 Assessment of the magnitude of exposed population for each group of EH factors	Census, land-use planning
Step 5 Assessment of the magnitude of risk groups included in each group of exposed population	Census
Step 6 Computation of health impacts in terms of morbidity and mortality	Results from risk assessment studies
Step 7 Definition of acceptable risks (or of significant health impacts)	Assessment of trade-off between human and economic requirements
step 8 Identification of efficient mitigation measures to reduce significant health impacts	Abatement of EH factors' magnitude, reduction of exposure, reduction of exposed populations, protection of risk groups
Step 9, Final decision Yes, if public health authorities are satisfied with proposed mitigation measures to control significant health impact No, if significant health impact was assessed and if doubt remains on the efficiency of proposed mitigation measures	

Source: Giroult, 1990

According to WHO (1979) some development projects through the ages have created hazards to health and consequently diseases. For example coal fired smog hanging over London in years past brought respiratory illnesses and crippling rickets. Also this organization reported that in one estimate in the 1970s, about 60,000 chemicals are in every day use and increase at the rate of some 200-1000 new chemicals per year. These substances may also appear in the environment as air, water and soil pollutants (WHO, 1979). Some examples of relationships between environmental health factors, exposure, risk groups and mitigating measures are illustrated in Table 5.6.2.

Health effects were direct and presented no conceptual problem for including within the EIA assessment framework. Health impact is quantitatively explained at different levels of physiological response and affected population size. According to the WHO (Go, 1987) usual human health and welfare concerns are as follows:-

a. Health Impact

- increased risk of morbidity and mortality from air pollution;
- contamination of water supplies and recreation water;
- contamination of shellfish harvesting areas and food chains;
- stress resulting from congestion and adverse environmental factors;
- risk from hazards and safety perception;

b. Welfare Impact (these are commonly referred to as induced socio-economic effects).

- noise;
- aspects of air and water quality problems affecting amenity and
- economic value of the resources;
- outdoor recreational services;
- public nuisance;
- demand on municipal infrastructures and services;
- aesthetics and social amenities;
- psychological features,
- population growth;
- open space and privacy;
- natural productivity.

Table 5.6.2 Examples of environmental health factors.

Air pollution
  Factors and their effects:
    inter dust (irritation of respiratory tracts)
    pathogens on aerosols (respiratory diseases)
    gaseous or suspended particulate toxic chemicals (carcinogenic effects)
    oxygen deficit (asphyxia)
  Exposure:
    people breathe indoor and urban air (pollution of higher atmosphere is not a health problem)

  Risk groups:
    people with chronic respiratory diseases

  Migration:
    abatement of emissions at source
    dispersion of pollutants *in the higher atmosphere*
    reduction in exposure of risk groups

Solid Wastes improperly disposed
  Factors and their effects:
    inert materials such as stone, glass and metal (injury hazard)
    toxic materials (human ingestion through water or food)
    organic fermentation products (favours growth of pathogens)

    food residues (increase population of disease animal vectors such as flies and rats)

  Exposure:
    contact with disease vectors
    contact with toxic materials
    consuming contaminated food water

  Risk groups:
    children playing on discharge sites
    garbage collection workers
    consumers of water from aquifers contaminated by leachate
    people within dispersal range of vectors

  Mitigation measures:
    proper selection of disposal sites
    fencing of disposal sites
    burying disposed waste under soil cover

Source Giroult, 1990.

5.7 The United Kingdom Approach to EIA

In Britain, interest has been shown in EIA since the early 1970s, but until 1988 when the EEC directive came into force there were no statutory requirements for any special form of Environmental Impact Assessment (HMSO, 1989). As interest in EIA grew in the 1970's a number of reports were commissioned by the Department of the Environment, for example Dobry (1975), calling for a more complete environmental evaluation of impacts. Probably the USA experience of EIA affected his recommendation that an EIS produced in Britain should take no more than ten weeks to produce and should be couched in non technical language. In this form the Environmental Impact Assessment would have the dual advantages of brevity and the ability to inform a wide, non technical audience. Local planning authorities are now obliged to appraise, among other things, measures for the improvement of the physical environment and how to integrate these in their plans for development and other uses of land. Special environmental impact assessments may be employed in major developments on the initiative of the developer or of the planning authority. The Government supports their use in appropriate cases together with industrial, social, health and safety, employment, land use and other implications (United Nations Economic Commission for Europe, 1979).

The " Environmental Assessment" booklet published by the Department of the Environment, Welsh Office, describes the procedures which apply to projects which fall within the scope of the EEC Directive and require planning permission in England and Wales (Her Majesty's Stationery Office, 1989). Schedule 1 types of development require environmental assessment in every case and include oil refineries, power stations, steel works and waste disposal installations for the incineration of special waste. Schedule 2 projects require EIA only if they are likely to have significant effects on the environment. Examples are salmon hatcheries, cement or glass factories, shipyards and breweries.

5.8 Methods of EIA

In the literature, there is no single "best" methodology for environmental impact assessment. Many methods have been devised to aid the preparation of environmental impact statements. Reviewers of impact assessment methods believe that there are five parameters which must be considered in any assessment (Munn, 1975; Bisset, 1987), (see 5.4) these are as follows:-

1. Impact identification.
2. Impact prediction and measurement.
3. Impact interpretation or evaluation.
4. The communication of information on impacts to decision-makers and the public.
5. Impact monitoring and mitigation measures.

As there is no standard method, it is very important, that "cook-book" methodologies are not blindly followed, and that methods are improvised to suit local conditions and limitations. These methods are fully described and discussed by McHarg, 1968; Leopold et al., 1971; Dee et al., 1972; Ditton and Goodale, 1972; Welch and Lewis, 1976; Clark, et al., 1978 and 1979; Sondheim, 1978; Thor, 1978; Bisset, 1980, 1983, 1986, 1987, and 1989; Turner and O'Riordan 1982; *Chapman, 1981; Lee, 1983; Clark et al.,* 1984; Ahmad and Sammy, 1985; Canter, 1986; Wathern, 1988.

There are many methods for making an environmental impact assessment. Attention will be focused in this section on the main methods of EIA. These techniques can be listed as follows:-

a. Ad hoc methods
b. Checklists
c. Matrices
d. Overlays
e. Networks
f. Quantitative methods or index methods
g. Models
k. PADC method

a. Ad hoc methods

Ad hoc methods clearly afford certain advantages. They are flexible in that the scope of the investigation can be expanded or contracted in response to any preliminary data which is collected. This system permits the latest technical developments in impact assessment to be utilised if required. Ad hoc methods are usually developed for a particular EIS by those conducting the assessment and the results may not be comparable with other related developments. These methods offer minimal guidance to impact assessment beyond suggesting broad areas of possible impacts for instance, impacts on flora and fauna, impacts on trees, impacts on water and any other factors (Warner and Bromley, 1974; Warner and Preston, 1974).

b. Checklists

A variety of checklist methods are available including simple descriptive and scaling and weighting checklists (Canter, 1977; Bisset, 1987). These list environmental agents present in the locality in which a development is planned and which are likely to be affected by the development. Checklists have primarily been used for the environmental, social and economic components to identify parameters and factors which need to be considered in detail. Table 5.8.1 illustrated a checklist for example. This method (Simple checklists) provides a specific list of environmental parameters to be investigated for possible impacts, but does not require the establishment of direct cause-effect links to project activities. They may or may not include guidelines about how parameter data are to be measured and interpreted (Warner, Preston, 1974). The other main purpose has been to ensure that assessments are sufficiently comprehensive and do not neglect any important parameters.

According to Bisset (1987) descriptive checklists present guidance on assessment. These are helpful for identifying impacts, inventory, prediction and analysis, and the evaluation of impacts and the comparison of alternative plans.

Table 5.8.1 Typical Simple Checklist

PHYSICAL

1. Geology
1.1 Unique Features
1.2 Mineral Resource
1.3 Slope Stability/Rockfall
1.4 Depth to impermeable Layers
1.5 Subsidence
1.6 Consolidation
1.7 Weathering/Chemical Release
1.8 Tectonic Activity/Vulcanism

2. Soils
2.1 Slope stability
2.2 Foundation support
2.3 Shrink-Swell
2.4 Frost Susceptibility
2.5 Liquefaction
2.6 Erodibility
2.7 Permeability

3. Special Land Features
3.1 Sanitary Landfill
3.2 Wetlands
3.3 Coastal Zones/Shorelines
3.4 Mine Dumps/Spoil Areas
3.5 Prime Agricultural Land

4. Water
4.1 Hydrologic Balance
4.2 Ground Water
4.3 Ground Water Flow Direction
4.4 Depth to Water Table
4.5 Drainage/Channel Form
4.6 Sedimentation
4.7 Impoundment Leakage and Slope Failure
4.8 Flooding
4.9 Water Quality

5. Biota
5.1 Plant and Animal Species
5.2 Vegetative Community
5.3 Diversity
5.4 Productivity
5.5 Nutrient Cycling

6. Climate and Air
6.1 Macro-Climate Hazards
6.2 Forest and Range Fires
6.3 Heat Balance
6.4 Wind Alteration
6.5 Humidity and Precipitation
6.6 Generation and Dispersion of Contaminants
6.7 Shadow Effects

7. Energy
7.1 Energy Requirements
7.2 Conservation Measures
7.3 Environmental Significance

Continue Table 5.8.1

SOCIAL

8. Services
8.1 Education Facilities
8.2 Employment
8.3 Commercial Facilities
8.4 Health Care/Social Services
8.5 Liquid Waste Disposal
8.6 Solid Waste Disposal
8.7 Water Supply
8.8 Storm Water Drainage
8.9 Police
8.10 Fire
8.11 Recreation
8.12 Transportation
8.13 Cultural Facilities

9. Safety
9.1 Structures
9.2 Materials
9.3 Site Hazards
9.4 Circulation Conflicts
9.5 Road Safety and design
9.6 Ionizing Radiation

10. Physiological Well-Being
10.1 Noise
10.2 Vibration
10.3 Odour
10.4 Light
10.5 Temperature
10.6 Disease

11. Sense of Community
11.1 Community and Organization
11.2 Homogeneity and Diversity
11.3 Community Stability and Physical Characteristics

12. Psychological Well-being
12.1 Physical Threat
12.2 Crowding
12.3 Nuisance

13. Visual Quality
13.1 Visual Content
13.2 Area and Structure Coherence
13.3 Apparent Access

14. Historic and Cultural Resources
14.1 Historic Structures
14.2 Archaeological Sites and Structures

Source: Bisset, 1991.

A Scaling checklist consists of a list of environmental elements or resources such as air quality, water quality, accompanied by criteria which express values of these resources. This method typically encourages the assignment of best-to-worst rank to each of the alternatives relative to each of the other items in the checklist (see Chapter 10).

Dee et al. (1972) reported the Scaling Weighting checklist developed by the Battelle Columbus Laboratories in USA (Lohani and Halim, 1987).

The Environmental Evaluation system is used to evaluate the future condition of environmental quality 'with' and 'without' the project. A difference in Environmental Impact Units (EIU) between these two conditions constitutes either adverse (loss in EIU) or useful (gain in EIU) impact. Mathematically this process can be described as follows (Lohani and Halim, 1987) :-

$$E_I = \Sigma^m_{i=1} (V_i) W_i - \Sigma^m_{i=1} (V_i)2 W_i$$

Where

E_I = environmental impact

(V_i) = value in environmental quality of parameter i with the project.

$(V_i)2$ = value in environmental quality of parameter without the project.

W_i = relative weight (importance) of parameter i,

m = total number of parameters.

A " Questionnaire" is one type of checklist. This method has the following advantages:

1. Checklists can be used as screening devices and are thus used to highlight environmental impacts.
2. They present a visual representation, which is easy to read, of the relationship between a proposed operation and any predicted impact.
3. Checklists can be expanded or contracted according to the requirements of the situation; they are flexible.

In descriptive checklists no emphasis is given to the relative importance of the various environmental characteristics. Scaling checklists include potential confusion over the scaling approach and the focus of attention on numeric indicators of impact scale to the exclusion of any consideration of real impacts.
The main disadvantage of checklists is that they are limited because they usually only concentrate on one side of impact identification.

c. Matrices

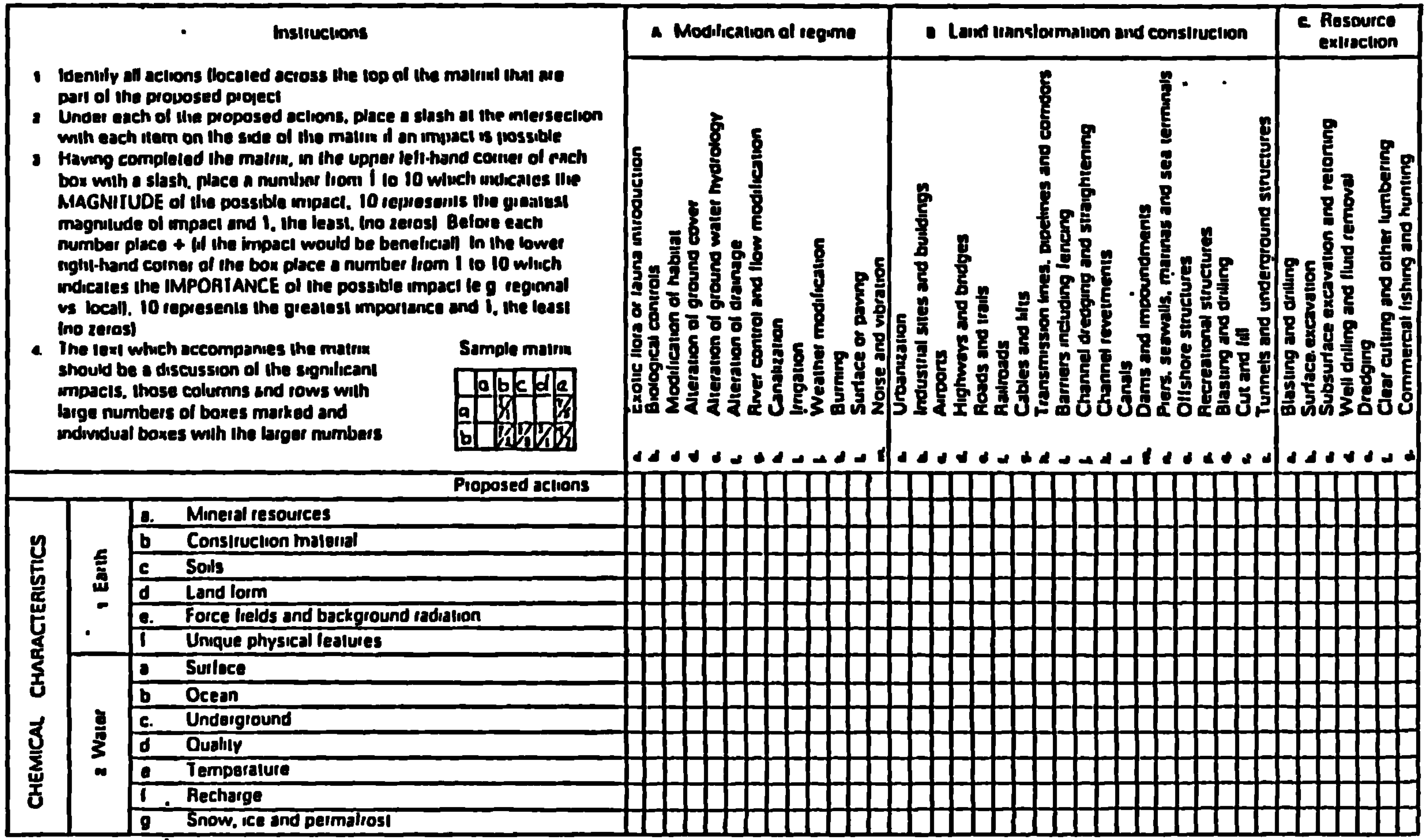
A matrix is a more sophisticated tool than a simple checklist. Often one dimension of a matrix is a list of environmental, economic and social factors likely to be affected by a proposal. The other dimension is a list of actions associated with the development. The most notable of these methods is the matrix developed by Leopold and his colleagues (Leopold et al., 1971). Figure 5.8.1 illustrates how the Leopold matrix can be used in the assessment. The Leopold matrix is comprehensive in covering both the physico-biological and socio-economic environmental impacts.

The cells of the matrix representing an interaction between a component and action are bisected diagonally. Impacts are investigated and scored subjectively by experts on a 1 to 10 basis where 1 is the least magnitude or importance and 10 the greatest. The score for magnitude is placed in the top left hand corner of each cell and the score for importance placed in the bottom right hand corner. The main purpose of the Leopold matrix is the identification of impacts and the determination of their magnitude and importance (Leopold et al., 1971). The Matrix method has been developed and modified in a number of different ways, for instance Baumgold and Enk (1972).

This method is perhaps the most appropriate approach for the assessment of EIA. Although it has a number of limitations, it may often provide helpful initial guidance in designing further studies. The Leopold matrix has been criticised by several authors and organizations, for example, Andrews, 1973; Environment Canada, 1974; Munn, 1979. They have pointed out that the Leopold matrix does not preserve the principle of mutual exclusion and there

Figure 5.8.1

A SECTION OF THE LEOPOLD MATRIX (COURTESY US GEOLOGICAL SURVEY)



Source: Clark, et al., 1978

is substantial possibility for double counting which is a shortcoming of the Leopold matrix in particular rather than of matrices in general.

This approach can accommodate both quantitative and qualitative data but it does not provide a means for discrimination between them. The time variable does not find consideration in this approach i.e. the matrix does not distinguish between immediate and long-term impacts nor between temporary and permanent or definite and indefinite ones.

The magnitudes of the predictions are not related explicitly to with-action and without-action future states. Objectivity is not a strong feature of the Leopold matrix and users are free to develop their own ranking system on a numerical scale ranging from 1 to 10, which is a subjective approach.

d. Overlays

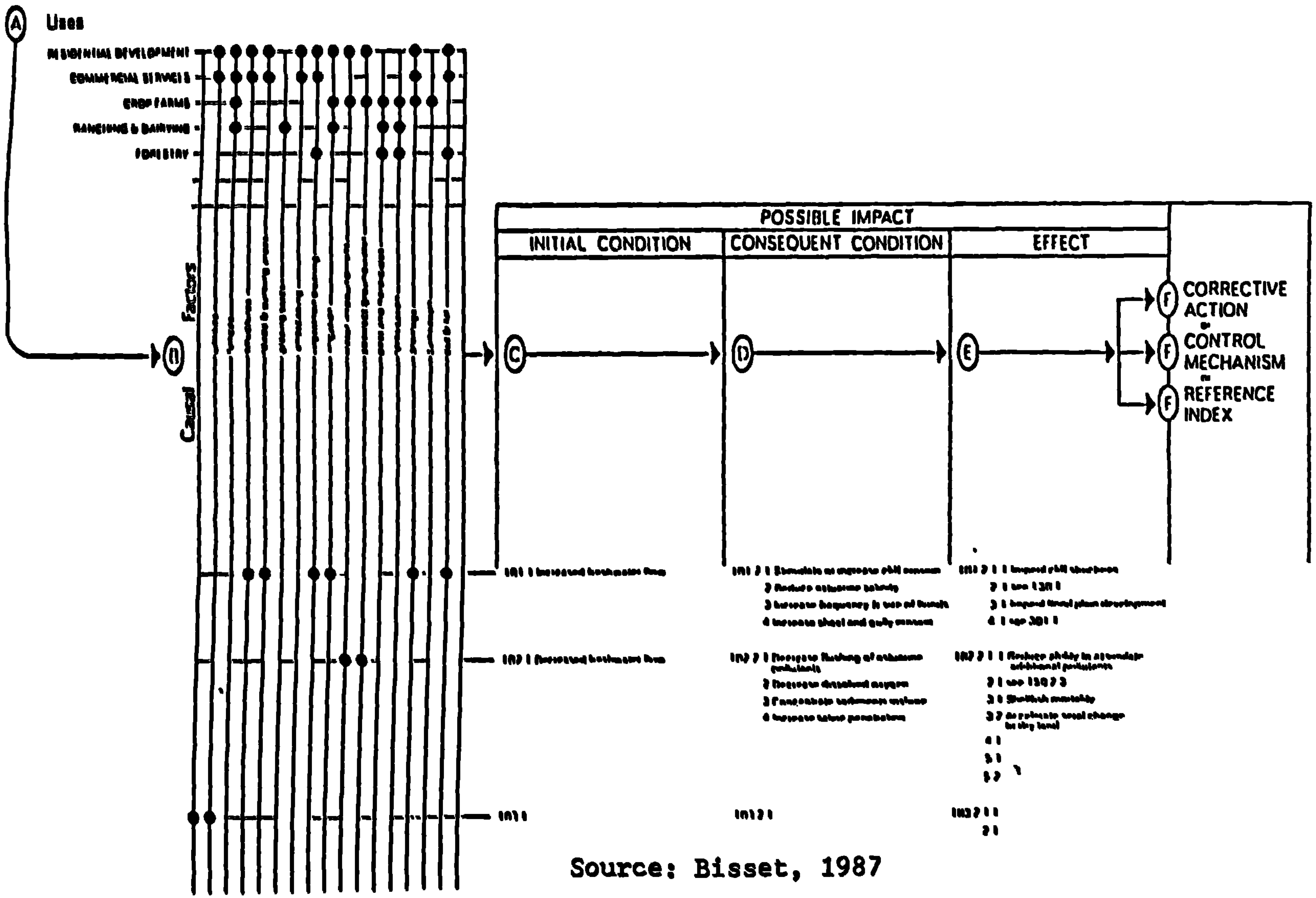
Overlays were developed in project planning. McHarg (1968) was one of the first to use them in impact assessment. In this method, a series of overlaid map transparencies can be used to help identify, predict and communicate the intensity and geographical extent of impacts. This method relies on a set of ecological, physical, aesthetic and social environmental characteristics for a project area. A study area is divided into appropriate spatial units and information on a number of attributes, such as environmental factors and human activities, is collected. Each map is prepared using a variety of colours to portray different conditions, qualities and values. The quality of each attribute is indicated by the depth of colour used, with the highest quality illustrated by the lightest colour. Overlays have been used exclusively for route selection (McHarg, 1968). Computers can be used not only to store comprehensive data on a local area, but also to provide composite maps incorporating a large number of characteristics of the proposed developments and the surrounding area (McHarg, 1968). This method is suitable for showing the spatial dimension of impacts but is less successful in dealing with other impact features such as probability and time and reversibility.

e. Networks

The first network was developed by Sorensen (1971) to help planners reconcile conflicting land-uses in the Californian Coastal Zone. These methods work from a list of project activities to find case-condition-effect networks. These methodologies are based on known linkages within systems. Thus, actions associated with a project can be related to direct and indirect impacts. These methods attempt to identify second and higher order impacts (Clark et al.,1978). The Sorensen network is an example of this method. Figure 5.8.2 illustrates a section of the network which deals only with impacts on water quality. Water is one of the six environmental factors, the others being climate, geophysical conditions, biota, access conditions and aesthetics. Networks are helpful for showing impacts which may arise from a project. This approach cannot identify all those which may happen (Warner and Preston, 1974; Bisset, 1987).

Figure: 5.8.2

SECTION OF SORENSEN NETWORK



Source: Bisset, 1987

f. Environmental evaluation system

Certain methods attempt to quantify all impacts so that total scores for a number of alternatives can be derived, for example, the Environmental Evaluation System (EES), (Dee et al., 1973). These methods are based on a list of factors thought to be relevant to a particular proposal and which are differentially weighted for importance. This method is based on a checklist of 78 environmental and socio-economic parameters. One thousand weighting units are distributed amongst these parameters by experts, for instance, existing levels of dissolved oxygen are normalised on a common scale of environmental quality (0-1) using value factions (Dee et al., 1973).

g. Models

Simulation models have been used to predict the effects of changes in environmental systems. The construction of a model involves the identification of the scope of the problem by a multidisciplinary group of scientists, planners and systems analysts. Existing information resources and additional data requirements are then assessed. There are few examples of models which have been utilized in the assessment of the wide variety of impacts resulting from most major projects (Clark et al., 1978). Bisset (1987) reported that Simulation modelling is based on the study of Holling and his colleagues at the Institute of Animal Resource Ecology at the University of

British Columbia, Canada (Bisset, 1987). Models can range from simple linear extrapolation to complicated energy system diagrams

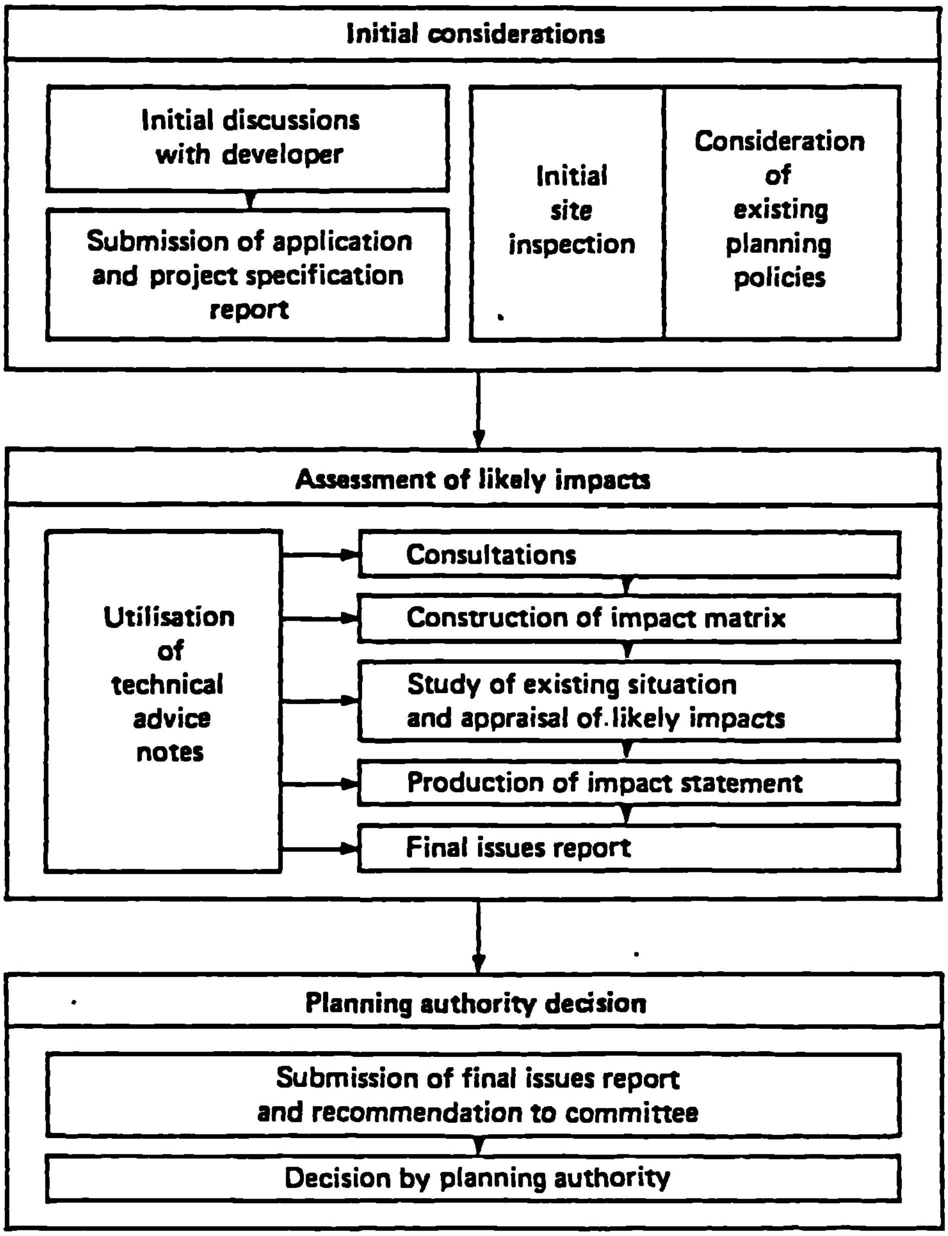
k. PADC Method

This approach was prepared by the Project Appraisal for Development Control (PADC) research group at Aberdeen University (Clark et al., 1976 and 1981). This method was produced in an attempt to resolve two problems encountered by UK Planners assessing proposals, namely, those of obtaining sufficient detailed information from prospective developers and the lack of systematic procedures for the appraisal of proposals. The PADC method comprises three activities, collecting of information, identification of likely impacts and appraisal of these impacts. Figure 5.8.3 illustrates linked activities in the PADC approach.
This method relies upon checklists and matrices.

5.8.1 The criteria for a comprehensive EIA

Several methods have been produced and developed for the presentation of environmental impact results to decision-makers and the general public. According to Atkins (1984) a review of environmental literature identified the following criteria which different writers claim are needed for a complete EIA (Warner and Bromley 1974; Munn, 1975; Catlow and Thirlwell, 1977; Clark et al., 1978.)

Figure 5.8.3 Linked activities in the PADC Methed



Source: Clark et al., 1978

a. An approach should be flexible to accommodate various objectives of decision-makers;
b. A method should be screened to identify projects likely to cause significant impacts;
c. A method should be a comparison of alternatives;
d. An approach should produce identification of environmental factors likely to be affected in specified geographical areas.
e. A technique should identify the interaction between impacts including induced impacts, synergetic, potentiating and dampening interactions;
f. A method should identify both positive and negative effects;
g. An approach should forecast the degree and timescale of the abrogation of the impacts and the commitment of natural resources;
h. A technique should evaluate impacts in terms of magnitude and significance;
i. A method should identify hazard and risks;
j. A technique should recognise the uncertainties inherent in the information base and the predictive accuracy;
k. A method should provide consideration of the validity of the results obtained.
l. An approach should identify the monitoring required during implementation and operational phases of the project;
m. A technique should provide separate assessments for various timescales such as the construction, operation

and post-operation periods;

n. A method should provide efficient communication of these findings and the use of time, money, data and personnel (Atkins, 1984).

In any development project assessment, a suitable decision-making tool is necessary for judging the environmental viability of the proposed project, along with economic and engineering feasibilities. For this purpose, many EIA methodologies have developed various decision-making aids, which are classified by Prasartseree (1982) under six factors, namely, impact magnitude; impact prevalence; impact duration and frequency; impact risk; impact importance and impact mitigation. The Author has modified that classification to give the six methods shows in figure 5.8.4.

Figure 5.8.4 Comparison of six EIA methods

Factors	Simple checklists	Overlay	Network	Leopold Matrix	Models	PADC
Magnitude	-	+	+	+	+	+
Prevalence	+	+	+	+	+	+
Risk	-	-	-	+	+	+
Importance	-	+	+	+	+	-
Mitigation	-	-	+	-	-	+
Flexibility	-	-	-	+	+	+

+ Satisfies criterion

- Does not satisfy

Source: After Prasartseree, 1982.

All methods of Environmental Impact Assessment have strengths and weaknesses. It is suggested, however, that the availability of a wide range of methods is a healthy situation in that there is a plentiful opportunity for researchers or planners to select an approach which is best suited to their needs.

5.9 EIA in the Islamic Republic of Iran

There is no statutory requirement for any specific form of environmental impact assessment in the Islamic Republic of Iran. But in June 1974, the Iranian Parliament legislated for Environmental Protection, and passed the National Clean Air Regulation in July 1975 an appendix to the Environmental Protection and Enhancement Act. These regulations described the duty of the Department of the Environment in the task of controlling and mitigating air pollution.

The legislation of 1974 established the Environmental High Council of Iran and created the Department of the Environment, which organization was connected to the Office of the Prime Minister. In 1990 this organization was directly attached to the Office of the President of Iran.

CHAPTER SIX

A CRITIQUE OF THE ENVIRONMENTAL IMPACT ASSESSMENTS DOCUMENT SUBMITTED BY ENVIRONMENTAL TECHNOLOGY CONSULTANTS LTD.

6.1 Introduction

The proposed hospital incinerator at Hammond Road, Kirkby industrial estate, Knowsley, Merseyside has raised a considerable controversy in the recent past. In 1989 an EIA of this proposed solid waste treatment plant was conducted by M/S Environmental Technology Consultants Ltd (ETC) on behalf of M/S Waste Management Ltd., who expect to install the proposed incinerator. Consequently, in December 1989 M/S ETC submitted a comprehensive document entitled " AN ENVIRONMENTAL IMPACT ASSESSMENT ON BEHALF OF WASTE MANAGEMENT LIMITED FOR THE CONSTRUCTION AND OPERATION OF A HOSPITAL INCINERATOR AT HAMMOND ROAD, KIRKBY INDUSTRIAL ESTATE, KNOWSLEY, MERSEYSIDE". Though it has been claimed that the document provides a complete EIA of the proposed incinerator, it suffers from some serious shortcomings. Consequently, although the document may help M/S Waste Management Ltd in obtaining a clearance from the authorities, it is also bound to attract criticism. A close scrutiny of the report indicates that certain issues have been ignored, some points have been partially covered while still others have been incorrectly interpreted.

The first step of installing a hospital incinerator is planning so that forecasts can be made and steps taken to prevent potential health and safety hazards. As it is proposed to site the incinerator on a industrial estate care must be taken to minimize the risk to nearby factory workers.

Planning should be organized into three phases; developing an organizational structure for site operations, instituting a work plan that considers each specific stage and a health and safety plan.

6.2 Siting of incinerator

The correct location and siting in the form of a grid reference is an essential prerequisite to any EIA study, otherwise interested members of the public and those concerned will not know the exact location. Unfortunately, the ETC has probably failed to recognise the significance of reporting the exactness of location. It would have been better if the incinerator location map had clearly shown the neighbouring residential areas, factories and farmland.

6.3 Environmental and social impact effects on people, facilities and industries in the vicinity of the incinerator

Fundamental information about the environment (natural and social) of an area and the details of the proposed development in that area along with its effect on the environment, are essential to conducting a proper EIA. However, the document in question ignores these aspects. In fact the environmental and social impacts should be considered at every stage.

6.4 Locations at risk from accident fumes

The surrounding area within a two kilometre radius is at risk. However, the report in question does not identify the following important locations which are likely to be affected by the fumes of an accident (which cannot be ruled out) :

6.4.1 The Neighbouring Industrial Estate

The workers as well as the industrial processes may be adversely effected by the continuous emissions from the incinerator.

6.4.2 Playing Fields in South , South-East, South-West and Sports Grounds in North-West.

These places were created to improve the health and physique of the people living in this area. However, the exposure to incinerator emissions during play may cause serious health problems pertaining to respiratory and circulatory systems. The already existing industrial emissions are likely to be aggravated by the incinerator emissions.

6.4.3 The Farms and Plantations

Coddick's Farm and Top House Farm in the East, Moss Lane Farm in the West and Ashcroft's Plantation in the North, though not mentioned in the report, may suffer crop damage from the stack emission from the incinerator.

6.5 Consultation

It is regrettable that the important issue of health and safety of workers at the incinerator has been altogether neglected. Though the ETC has consulted a number of agencies during the process, for reasons unknown, neither the people of neighbouring areas were consulted nor the health aspects of other incinerator workers was taken into account. Such an attempt could have helped in promoting a correct understanding among the people living in Kirkby.

6.6 Non adaption of a matrix

Though the failure to adopt a matrix approach on the part of ETC cannot be criticised, according to the guidelines for Environmental Assessment issued by the DOE, the adoption of a matrix would have ensured the identification of impacts in a more systematic manner.

6.7 Baseline measurements

As part of the ETC document, in Sept. and Nov. 1989, ETC along with other authorised consultants initiated some baseline monitoring programmes including noise level and ambient air quality. Although they form part of a comprehensive evaluation of the existing environmental data, certain other factors such as temperature and direction of wind have not been taken into consideration; they affect the emissions and their fallout.

6.8 Siting of this incinerator

As Waste Management Ltd. proposed to build the hospital incinerator on their existing site on the industrial estate ETC. suggest it is no more dangerous a risk than an industrial incinerator. ETC has used the excuse that the proposed incinerator is going to be installed in an industrial area. This is not valid as incineration is neither an industry nor can it be granted immunity from the existing rules and regulations for pollution control. More so the siting of an incinerator in the industrial area is likely to effect the health of the working population in the industries of that area.

6.9 Distance between hospital incinerator and human settlements

According to international practice, the distance from the site of a development to the nearest human settlements along with its population should be considered. Such a practice helps in planning emergency rescue operations. This was ignored by the report.

6.10 Mitigation of undesirable effects

Under the title "Mitigation of undesirable effects", the Consultants have suggested remedial measures to curb the adverse effect of atmospheric emission. The use of a wet gas scrubbing system may be agreed to but the re-use of scrubber water after treatment needs elaboration. However, the treatment technology (which is likely to add to the cost of de-polluting the emissions) has not been explained.

6.11 Communication of the findings

ETC Ltd. compiled the findings of the study and communicated it as an environmental impact statement (EIS). This document may serve the purpose of satisfying the authorities but fails to offer any possibility of a dialogue with the local people. Consequently , there seems to be no possibility that the document in question will be able to help in winning public confidence and support.

6.12 Justification of choice of location

The document fails to justify the selection of the Hammond Road site. It merely states that this is being undertaken at a location which is most conveniently connected by road and falls in an industrial area. The insufficient data in terms of the proposed site's future development, visual intrusion, pollution effects and solid waste disposal barely satisfies the ETC's site selection criteria.

6.13 The proposed development and its overall implication

In Section 2 of the report, the justification for a hospital waste incinerator has been explained in a lucid manner but it would have been desirable if the classification of hospital waste on the basis of its origin could have been given. Such information would help in understanding the principle behind hospital waste incineration. Table 6.13.1 gives an idea about the feasibility of this method in waste disposal.

6.14 Causes and Control of pollution

M/S Waste Management Ltd. regards atmospheric emission as the single most important factor likely to cause pollution. Therefore, besides a gas control system, they propose to incorporate a wet gas scrubber to control atmospheric emission. However, the Consultant ETC Ltd, has preferred to follow the Gaussian Plume Model, contrary to the Industrial Source Complex (ISC) Model recommended by the United States Environmental Protection Agency (EPA, 1987). The proposed incinerator offered an opportunity to use the ISC model, but for reasons not stated ETC Ltd preferred the former.

TABLE 6.13.1 : Optimal clinical waste disposal methods recommended by various agencies.

Type or origin of the waste	CDC	JCAH	EPA
a. Microbiological	I/S	I/S	S
b. Blood & Derivatives	I/S	L	I/S
c. Isolation of Infective Diseases	I/S	L	I/S
d. Anatomical Parts	I	I	A/C/I
e. Excretion and Secretion	N	L	-
f. Contaminated Waste	-	I/S	I/S
g. Surgery Parts (dirty cases)	-	-	I/S
h. Dialysis Units	-	-	I/S

(Source: Amadio and Carlo, 1990)

Key:

A - Sterilisation with Incineration and Autoclave

C - Cremation L - Landfill

I - Incineration

N - Excluded

S - Sterilisation in Autoclave

CDC - Centre for Control of Infectious Diseases, USA.

JCAH - Joint Commission for Hospital Problems, USA.

EPA - Environmental Protection Agency, USA.

6.15 Estimation of pollutant concentration

The pollutant concentration at different distances and in all possible directions from the source has been calculated by using dispersion estimates. These values could have been used in plotting isopleths for different pollutants in the area, but for reasons best known to the consultants, it has not been attempted.

6.16 Monitoring Programme

The report contains scanty information about the monitoring programme. This is important for pollution free operation of the proposed incinerator.

6.17 Noise Levels

The report suggests that there would be no increase in noise level due to the installation of a incinerator. This is erroneous. Firstly, because the noise level was measured only for a small period and secondly, the increased road traffic due to constant transportation of waste is bound to increase the ambient noise level. The noise level will also require constant monitoring. The consultants have estimated the noise level at different points as follows:-

Point	Noise level
Outside Incinerator Building	55 dBA
Vicinity	71 dBA
At Proposed Site	62 dBA

Other noise producing industrial operations in the proposed area coupled with increased vehicular traffic are likely to add to the noise to be produced from the operating incinerator.

6.18 The effects on flora and fauna

Although the effect on flora and fauna are the most significant aspect of an EIA study, it lacks details, for example:-

a. "... Brown birches and moss plantations, both of which are much further from the proposed development."

b. "... two sites identified, Knowsley Park and the reservoir near Eccleston are much further away and will not be affected at all."

c. A statement such as "...there will be no impact on livestock" needs further scientific evidence. The noise level data as mentioned above will create a situation where birds might be scared away from the proposed site , thus causing an ecological imbalance.

6.19 The economics of the proposed incinerator

Looking to the economics of the proposed incinerator, ETC Ltd. advocates that the retrofitting of existing incinerators would be costly, therefore, this centralised incineration facility would cost less . However, the said statement has no supporting calculations.

6.20 Provision of Employment

It has been argued that the installation of the proposed hospital waste incinerator will provide employment to 12 persons during the construction phase and to 25 during operation. Lack of a commitment on the part of WML, indicates there will be few job opportunities for local workers.

Lastly, and most significantly is the failure of M/S Environmental Technology Consultants Ltd. in consulting and convincing the people of Kirkby in particular and of Merseyside in general that the place is not being converted into the "waste dumping ground" of the county.

CHAPTER SEVEN

CASE STUDY 1 KIRKBY, UK

7.1 Introduction

This chapter presents the findings of a survey carried out in Kirkby in September 1990. The aim of the survey was to obtain and understand the perceptions and concerns of local people in relation to installing a hospital waste incinerator in Kirkby. This information was intended to help the author to assess the environmental impacts of installing a hospital incinerator in Kirkby.

This chapter is divided into two main sections. The first discussed the background and health of Knowsley and the second presents the results of a survey and discuses them.

7.2 Background and health

7.2.1 General information about Kirkby

a. Location

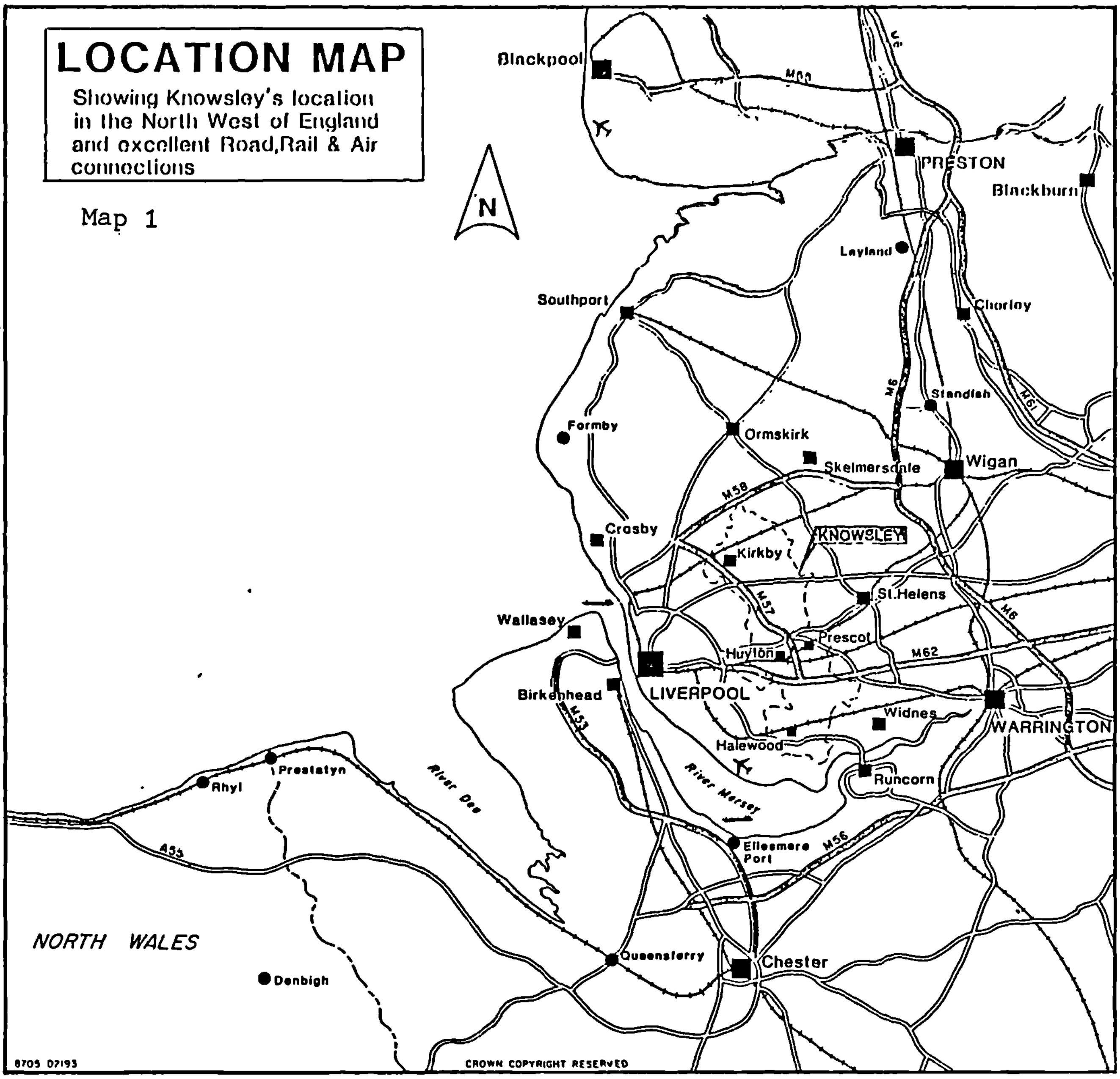
Kirkby is an inland town, situated about eleven kilometres North East of Liverpool Pier Head. Kirkby is bounded by the parishes of Sefton, St. Helens; the Metropolitan District of Liverpool; the County of Lancashire Knowsley Metropolitan District. The total area is sixty square kilometres (Information Centre, 1990). The location and boundaries of Kirkby city are presented in

Figures 7.1.1 and 7.1.2 (Maps 1 and 2).

b. History

Kirkby was established before Liverpool had an independent existence and was mentioned, as an existing township, in the Doomsday book (Grant, 1971). In Dugdule's Monasticon there are nineteen different places with the name of Kirkby yet the subject of the present study is not included (Moore, 1972). The name Kirkby is a word of Danish or Scandinavians origin, from "Kirkja" church, and "by" a fixed residence (Grant, 1971).

During the Second World War (1939 - 1945) the UK Government established a large Royal Ordnance Factory and purchased 750 acres of land in the eastern part of the area. The town was already linked to the national railway system, and more recently to the Motorway network by the M57. Kirkby Station is 5 miles from Liverpool. Kirkby was constituted an Urban District Council on April first 1958. Till 1922 the Parish of Kirkby was in West Lancashire which today consists of 20 districts (Moore, 1972). In 1941, the Royal Ordnance Factory was completed and by 1942 had increased its labour force to 20,000 with workers coming in from Southport, Wigan, Birkenhead, St. Helens and Liverpool (Moore, 1972). On 1st of April, 1974, Kirkby ceased to be an urban district of Lancashire County and became united with Huyton, Prescot, Knowsley, Whiston, Figure: 7.1.1 Location map

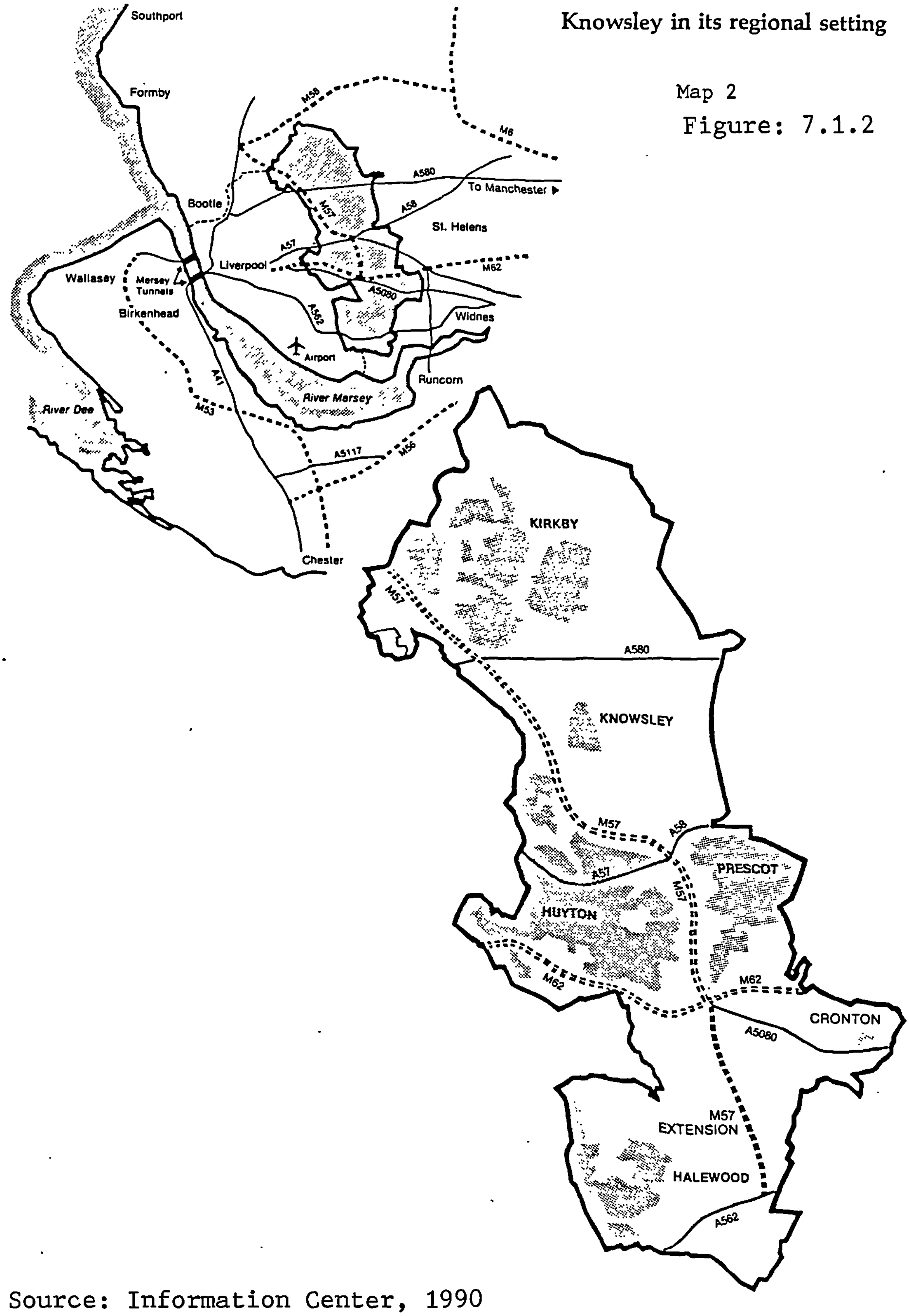


Source: Information Center, 1990

Knowsley in its regional setting

Map 2

Figure: 7.1.2



Source: Information Center, 1990

Cronton, Tarbock and Halewood to form the Metropolitan Borough of Knowsley in the new Metropolitan County of Merseyside (Merseyside Police, 1978).

c. Population

In 1801 the population of Kirkby was 833 but by 1987, the population of the Knowsley Borough had grown to 161,400, almost 200 times more, with the fastest growth occurring between 1951 and 1961. The variation in population of Kirkby between 1801 and 1851 was as shown in Table 7.2.1 It can be seen that during the first part of the Nineteenth century growth was slow.

Table 7.2.1 Kirkby population 1801-1851

Year	Population of males	Population of females	Total
1801	422	411	833
1811	474	438	912
1821	518	517	1035
1831	607	583	1190
1841	741	735	1476
1851	773	687	1460

Source: Moore, 1972

The population of the Kirkby area increased steadily from 1951 to 1971 and is given in table 7.2.2 This Table indicates that until 1951 growth remained slow. Rapid growth . occurring only when it become the centre of a new town taking people from central Liverpool.

Table 7.2.2 Kirkby population 1951-1971

Year	Population
1951	3210
1961	52139
1971	59918

Source Moore, 1972

Table 7.2.3 shows the distribution of the population (males and females) by age in 1987.

Table 7.2.3 Kirkby population distribution by age in 1987

Population	Males	Females	Total
0 - 4	290	281	571
5 - 14	549	504	1053
15 - 24	607	602	1209
25 - 34	574	579	1153
35 - 44	345	348	693
45 - 54	279	311	590
55 - 64	473	543	1016
65 - 74	267	305	572
75 - 84	74	111	185
85 +	7	27	34
Total	3465	3611	7076

Source: Information Centre, 1990

It is significant that 50 % of the population in 1971 was under the age of 22 years (1971 Census). From 1950 to 1970, the trends show that, there was an increase in the total population as well as in the economically active population, however, after 1981 there was a decrease in population (Figures 7.2.1 and 7.2.2).

7.2.2 Industries in the Kirkby area

Most industry is concentrated in the Knowsley industrial estate which is situated to the East of the M57 motorway and South of the East Lancashire road. During 1941 the Royal Ordnance Factory was completed and it is the nucleus of the present industrial estate. There are 421 companies on the estate.

A characteristic feature of Knowsley industrial estate is the manufacture of a great diversity of products. Table 7 3.1 shows briefly a list of these products. For a complete list of companies in Knowsley Borough see Jafari Mosavi, 1991.

Knowsley's Population
1961-1981

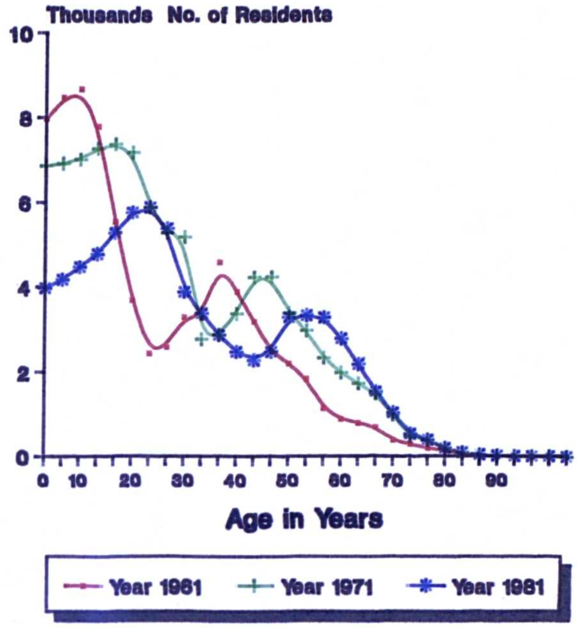


Figure : 7.2.1 Source: C.E.S. Limited, 1982

Total Population and Economical
Knowsley

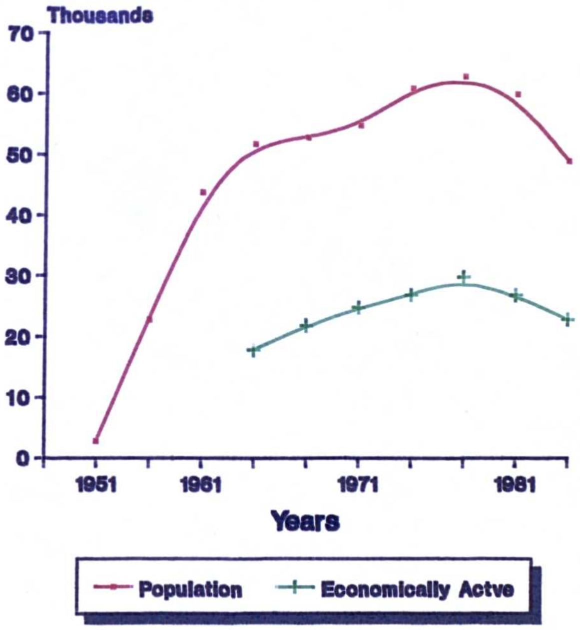


Figure : 7.[illegible] Source: C.E.S. Limited, 1982.

Table 7.3.1 Manufacturing activities in Knowsley Industrial Estate

* Engineering
* Wood and manufacture
* Clothing
* Concrete Utilities
* Paint research
* Electrical appliances
* Electric Locomotives
* Export Packing
* Box manufacture
* Furniture
* Bedding
* Upholstery
* Latex
* Motor Engineering
* Lift manufacture
* Food manufacture
* Steel tube Fabrication
* Cardboard and paper containers
* Soaps and disinfectants
* Printing machinery
* Roofing Felts
* Plastics
* Petrol Pumps
* Bottling
* Photographic chemicals
* Chemical manufacture
* Frozen Food
* Electrical Cable manufacture
* Domestic Appliances
* Car Components
* Trailers

7.2.3 Employment

In 1953, there were 7,500 people employed by 130 firms on the estate and by 1958 the employment had increased to 12,000. The 1981 census showed that there were 44% of employed Knowsley residents working in Knowsley, 36% in Liverpool, 3.4% working in St. Helens and 3.2 % in Sefton. It is interesting to note, that 4% of Sefton residents work in Knowsley and 9.4% of St. Helens residents work in Knowsley.

In 1987, Knowsley employed 9,336 full-time employees. Two years later it had reduced the total workforce by 5% to 8,893. The 1988 Chartered Institute of Public Finance and Accountancy (CIPFA) figures show that the average number of full-time employees per 1,000 population in metropolitan authorities is 32.93. Knowsley employs 37.75 placing it at 28 in a league table of 36. The metropolitan district average for part-time employees is 22.07. Knowsley employs 21.62 which makes it 15 on the league table (Parkinson, 1990).

Table 7.4.1 Employment in manufacturing in Knowsley, Merseyside and Great Britain

	Males	Females	Total
Knowsley			
Resident labour force (16 - retirement)	49,586 (100)	31,436 (100)	81,022 (100)
Unemployed (seeking work and temporary sick)	13,615 (27.5)	5,045 (16.1)	18,660 (23.0)
Youths (16-24) unemployed	5,074 (10.2)	3,110 (9.9)	8,184 (10.1)
Merseyside			
Resident labour force (16 - retirement)	414,989 (100)	266,064 (100)	681,053 (100)
Unemployed (seeking work and temporary sick)	82,901 (20)	31,467 (11.8)	114,368 (16.8)
Youths (16-24) unemployed	27,498 (6.6)	16,742 (6.3)	44,240 (6.5)
Great Britain			
Resident labour force (16-retirement)	16,744,000 (100)	15,383,800 (100)	32,127,800 (100)
Unemployed (seeking work and temporary sick)	1,761,270 (10.5)	722,166 (4.7)	2,483,436 (7.7)

source: 1981 Census

In 1981 there were 81,022 resident workers (Aged 16-retirement), 18,660 unemployed and 8,184 youths (16-24) unemployed in the Knowsley Metropolitan Borough. Table 7.4.2 shows the main details of economic activity in Knowsley area. Kirkby's economic base has been created over the last six decades from four main sources. First ,and most important, it is the arrival of large manufacturing plants drawn to Merseyside. A second group of newcomers were much smaller branch plants in ware housing, transport, storage, sales, distribution and retailing. Thirdly, there has been a continuous flow of branches and independent firms from the Liverpool-Bootle Dock area. Fourth, there have been a small number of firms setting up in Kirkby.

Table 7.4.2 Economic activity in Knowsley

Employed			
Residents aged 16 or over in employment	36,459	27,385	63,844
- Employees working part - time	634	10,768	11,402
- Self - employed	2,762	419	3,181
Employment profile			
Proportion of population in employment working in following socio-economic groupings:		%	
- Professional and Management (SEG 1- 4, 13) AB		8.2	
- Intermediate and junior non-manual (SEG 5.1, 5.2, 6) C1		29.4	
- Skilled manual (SEG 8, 9, 14) C2		24.6	
- Semi/ unskilled and other (SEG 7, 10, 11, 15, 16) DE		37.6	
- Armed Forces (SEG 16)		0.2	
Proportion of population in employment working in following industries			
- Agriculture, energy and water		1.7	
- Manufacturing		35.6	
- Constructing		6.9	
- Distribution and catering		15.5	
- Transport		7.5	
- Other services		31.8	

source: 1981 Census

The level of unemployment and vacancies is an important indicator of the health of an area's economy and provides an indication of the variation in the demand for and supply of labour in different areas. Table 7.4.3 shows the proportion of the economically active population with degrees and professional and vocational qualifications in Knowsley, Merseyside and Great Britain. Knowsley has a substantial set of economic and social problems which are typically associated with low attainment and poor performance in school (Parkinson, 1990).

Table 7.4.3 Proportion of economically active population with degrees, professional and vocational qualifications.

Knowsley	4.4 %	
Princess Ward, Huyton	0.9 %	*
Merseyside	9.8 %	
Great Britain: Males	13.2 %	
Females	12.2 %	

* lowest of all Knowsley Wards.

Source: 1981 Census.

Table 7.4.4 illustrates the proportion of the population employed in manufacturing in Knowsley and a comparison between Knowsley, Merseyside and Great Britain.

Table 7.4.4 Proportion of population employed in manufacturing

Knowsley	35.6 %
Merseyside	27.2 %
Great Britain	27.2 %
Cherryfield Ward, Kirkby :	47.6 % - highest of all Knowsley Wards

Source: 1981 Census.

7.2.4 Air pollution

There have been many definitions of air pollution but it is widely agreed that it is the introduction of dangerous or unwanted materials into the atmosphere. It is general agreement on to which are hazardous to health. It is, however, difficult to define what is objectionable since what is noticeable to some is unnoticed by others. It is also clear that most of Man's activities emit solids and gases into what is otherwise a fairly stable atmosphere.

The third annual report on the condition of the atmosphere in Mersyside concentrates on the condition of the atmosphere to be considered by the public protection committee. In general the levels of smoke recorded at National Survey Sites in Merseyside have continued to decline.

The average level recorded in Merseyside is now significantly lower than the World Health Organisation's recommended long-term goal and is no longer significantly higher than the UK average. The areas worst affected continue be the older centres of population but even here the situation is improving.

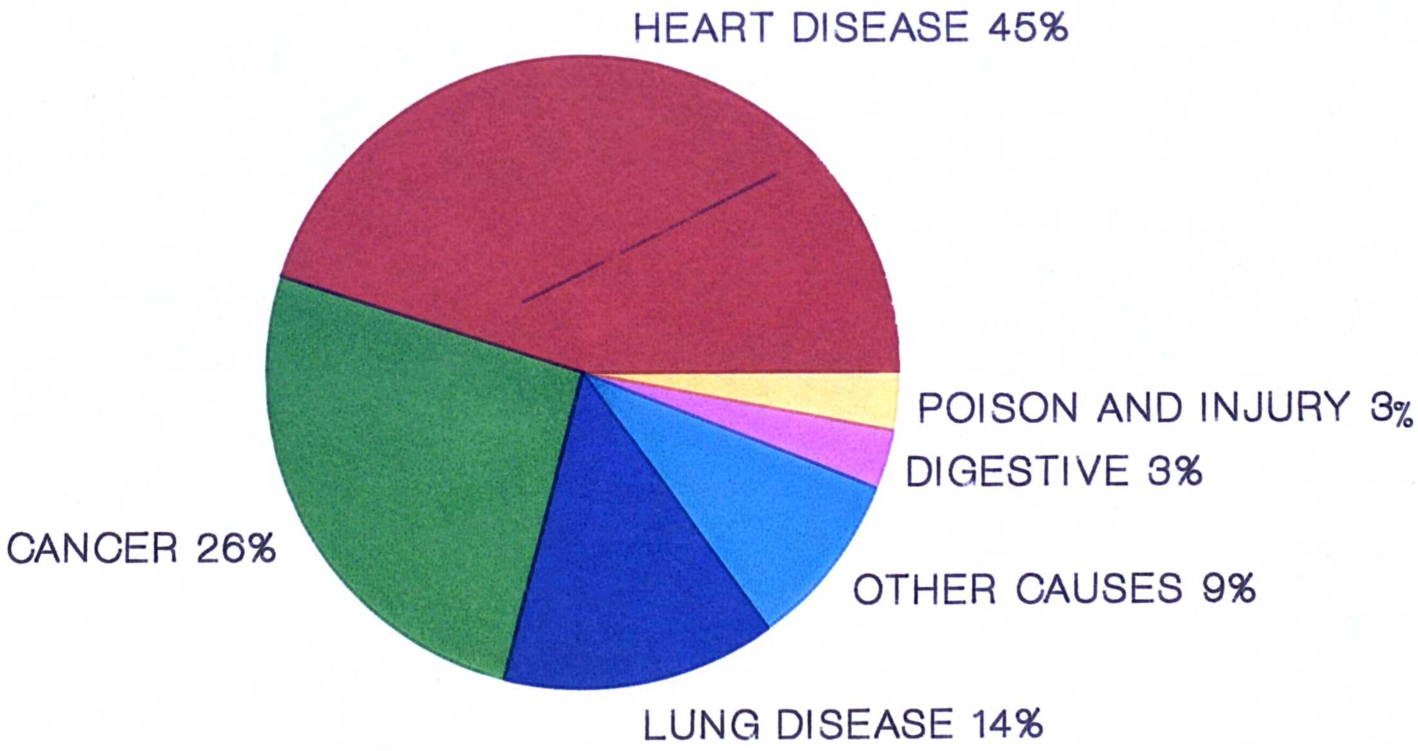
Merseyside still remains one of the most polluted areas in the U.K. and the average level of sulphur dioxide recorded is still well above the World Health Organization level. The levels of sulphur dioxide recorded in the urban areas of the County continue to decline, although the rate of improvement has also slowed in recent years. The measurement of sulphur dioxide at physical monitoring stations indicates a sustained improvement in atmospheric quality at these sites.

7.2.5 Public health in Knowsley

a. Introduction

A comprehensive study of health conditions requires knowledge not only of death rates and life expectancy rates for all age groups, but also of the distribution, by cause, of mortality and morbidity. The "Winds of change" literature which was presented to the Housing Committee in 1988 reported that the residents of Knowsley Borough have a rate of precipitate death some 15% above the national average; a rate which is amongst the highest in the U.K. The Report declared that between 1975 and 1984, of the 5125 deaths from all causes in that period, 1074 (20.1%) died precipitately from just two preventable causes; heart disease and cancer. In Knowsley, most preventable deaths (25%) are caused by lung cancer. This level of lung cancer deaths creates the unusual situation in Knowsley whereby women are more likely to die from lung cancer than of breast cancer. The traditional causes of diseases of the lungs, air pollution and working in mines, have made very little overall contribution to the death rates in Knowsley. A major factor associated with lung cancer is cigarette smoking. Heart disease causes 50% of preventable deaths in Knowsley. For women aged 25-44 the risk is double the national rate. Men aged 35-44 have death rates 56 % above the national rate. The recent public health reports of the District Health Authority emphasize that life expectancy for those who live in Knowsley is significantly less than that for the rest of the UK (Health Knowsley, 1991. by the year 2000). The specification of the reports which compare present health levels of residents in Knowsley with national death and sickness rates, is summarised in figure 7.6.1

Health Knowsley



Source: Health Knowsley, 1991. by the year 2000

Figure 7.6.1

In order to compare the mortality rates between communities, it is not enough to compare raw death rates only; the sex and age structure of the different communities must be taken into account. A standardised mortality Ratio (SMR) can be considered as a percentage. Therefore, 100 is always taken as the national average; figures over this are higher than national levels; less than 100 are below national levels. Table 7.6.1 shows the average standardised mortality ratio from 1983- 1985 for Knowsley and Mersey region.

Table 7.6.1 Standardised Mortality Ratios (All causes)

Year Area	1981	1982	1983	1984	1985	1986
Knowsley	105	126	118	114	113	107
Mersey	103	107	109	110	111	111
Nation Average	100	100	100	100	100	100

Source: ST Helens & Knowsley Health Authority, 1988.

Figure 7.6.2 and 7.6.3 (Graph) compares the mortality experience of Knowsley with the National average.

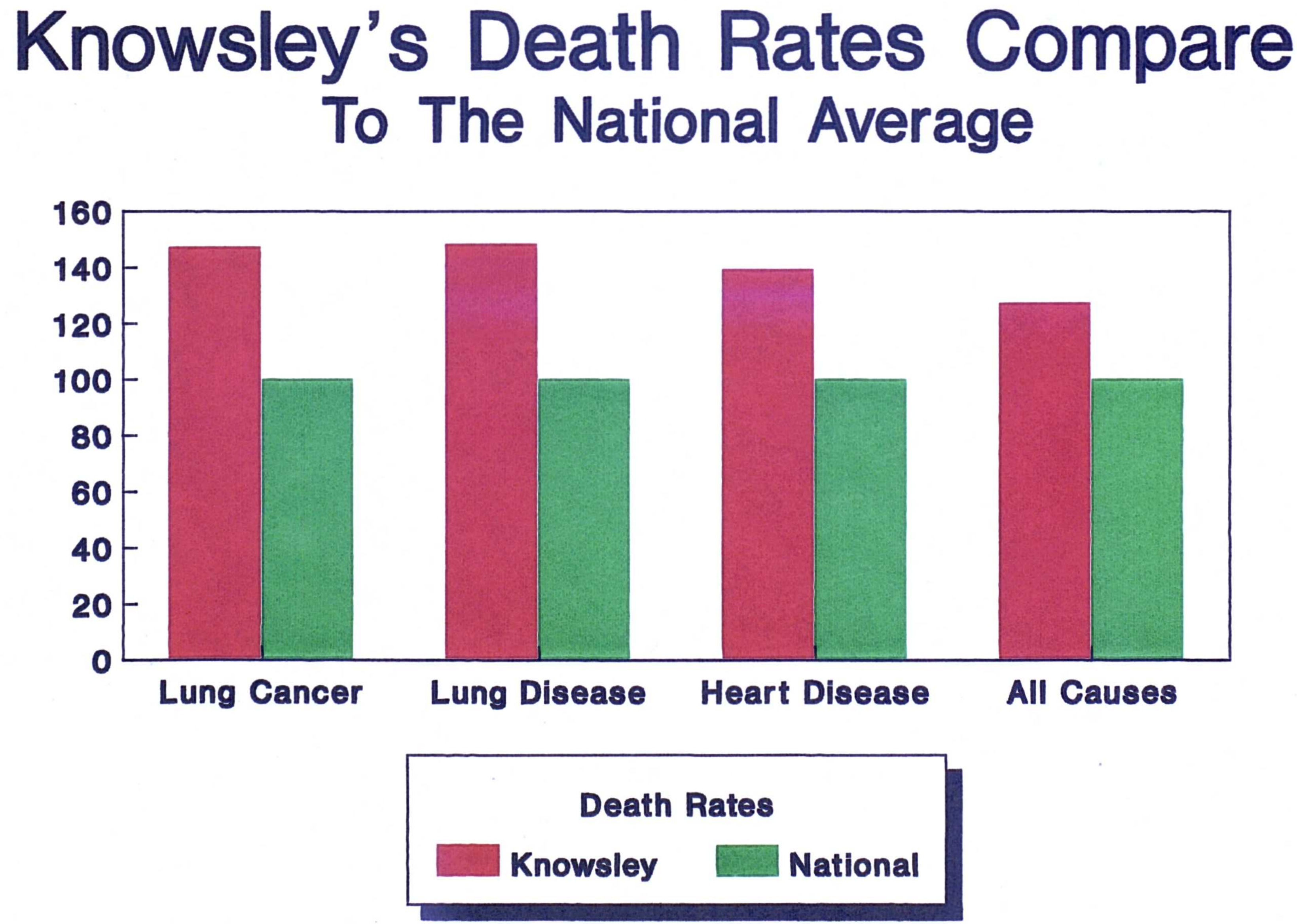
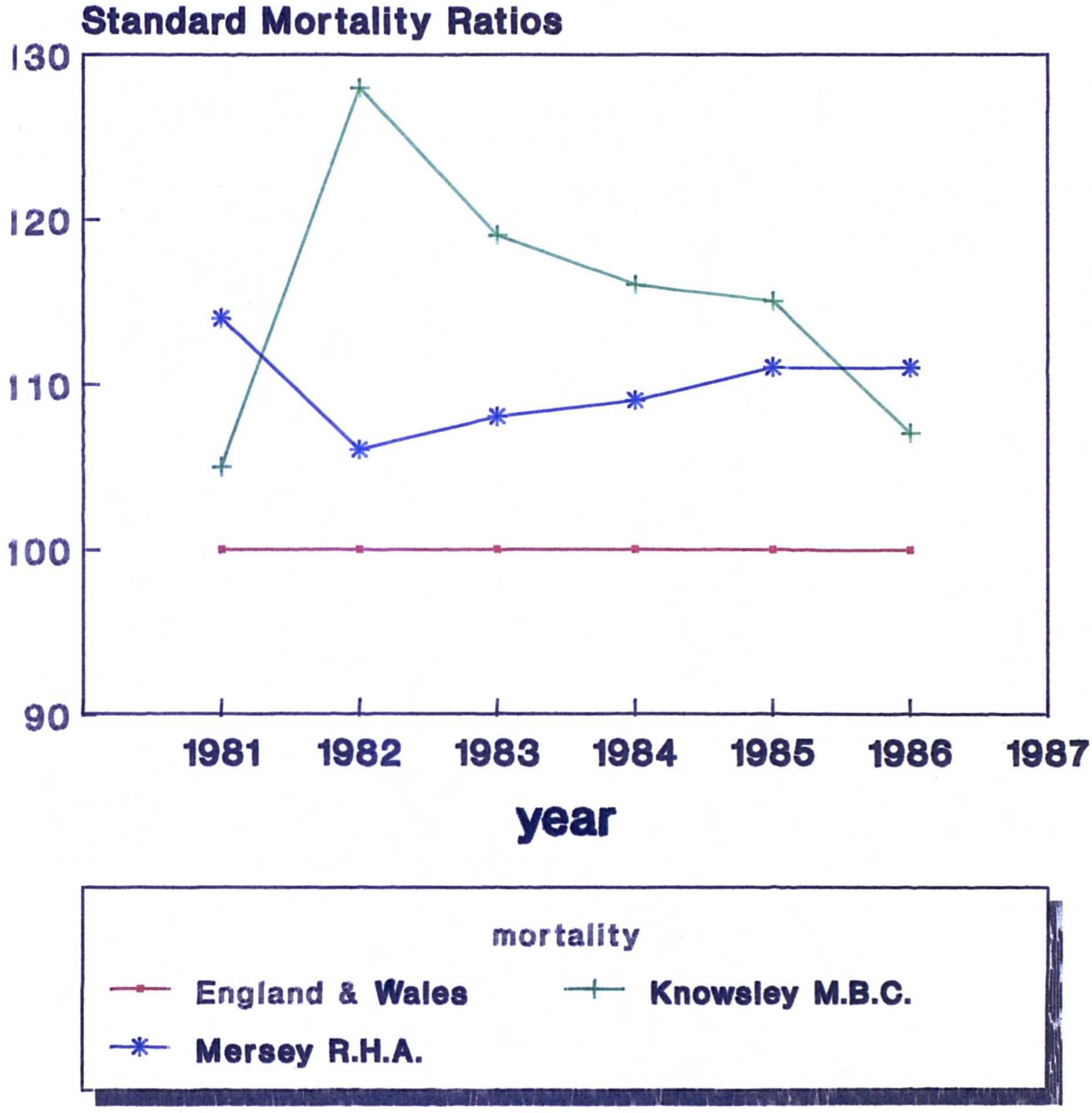


Figure 7.6.2 Source: Health Knowsley by the year 2000, 1991

Standardised Mortality
All Causes



Source: St. Helens & Knowsley Health Authority, 1988

figure 7.6.3

The standardised mortality ratio (SMR) for Knowsley includes deaths within long-stay institutions in the borough. Table 7.6.2 shows SMR's for deaths from all causes and at all age levels, for wards in Knowsley between 1983 and 1985.

Table 7.6.2 SMRs for deaths from all causes for wards in Knowsley

Wards	SMR's
Whiston	142
St Gabriel's	128
Halewood South	125
Kirkby Central	125
Long view	122
Cherryfield	122
Northfield	117
Park	117
Whitefield	114
Prescot East	111
Princess	108
Roby	108
Prescot West	106
Halewood west	106
St Michael's	105
Whiston South	101
Tower Hill	101
Page Moss	98
Knowsley Park	96
Swanside	92
Cantril Farm	87
Halewood East	83

Source: St. Helens & Knowsley Health Authority, 1988.

b. Birth and Infancy:

i. Perinatal Mortality

Perinatal mortality rates have fallen for the United Kingdom although they have lagged behind those in many other countries, particulary Japan and Scandinavian countries. The rate for England and Wales has declined gradually from 17.7 per 1,000 births in 1976 to 9.6 in 1986. The Mersey Region has also followed the same trend and the rate has declined from 19 per 1,000 births in 1976 to 10.2 in 1986. Knowsley had a higher perinatal rate in 1976 (22 per 1000 births) but this fell to 10.2 in 1986.

ii. Infant mortality

It is unexpected that Knowsley has generally a Infant Mortality Rate lower than England and Wales and the Regional Health authority. The infant mortality for Knowsley Metropolitan Borough for the years between 1984 and 1986 shows 47 deaths. There is no real difference in perinatal mortality rate between England and Wales and Knowsley, but the rate of decline in perinatal mortality in Knowsley has been faster than in England and Wales.

c. Major Causes of death

An investigation of mortality figures for 1982 to 1986, obtained from death records, clearly shows the major causes of death in this borough. These are diseases of the circulatory system, respiratory diseases and neoplasms, and are shown in detail at Table 7.6.3.

Table 7.6.3
Major causes of death - Knowsley Metropolitan Borough, 1982-1986

Disease	Total No in 5 Years	Average	Percent
1. Diseases of Circulatory system	3620	724	45
2. Neoplasm	2125	425	26
3. Diseases of Respiratory system	1167	233.4	14
4. Injury and Poisoning	258	51.6	3
5. Diseases of Digestive system	249	49.8	3
6. Diseases of Genito-urinary system	112	22.4	1

Source: St. Helens & Knowsley Health Authority, 1988.

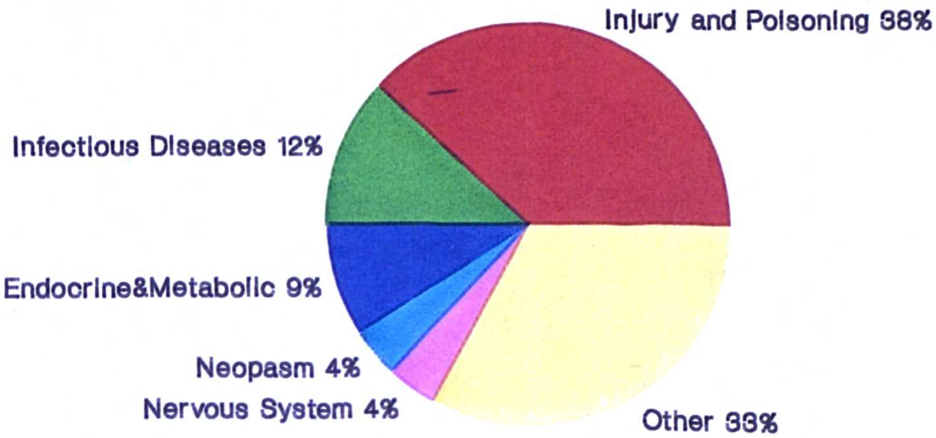
d. Causes of death by age

A breakdown of the mortality data for this borough by specific disease and age group, up to the age of 70 years (with the assumption that many of the deaths up to 70 years of age are preventable) was carried out. The following information was obtained. Major causes of death in Knowsley for age groups (1-14), (15-34), (35-54) and (55-69) are shown in figures 7.6.4, 7.6.5, 7.6.6 and 7.6.7.

e. Causes of death by gender

Information on all causes of death for 1982-1986 for both sexes was obtained from the Office of Population Censuses and Surveys (OPCS). The specific causes of death

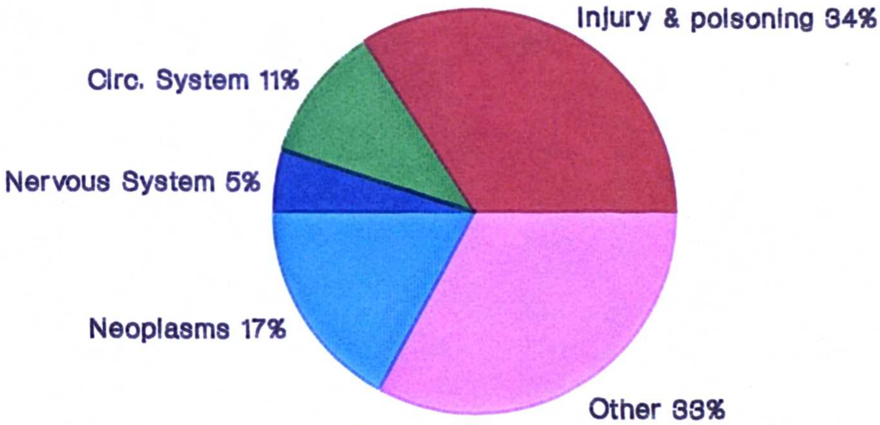
Most Common Cause Of Death
Age Group - Knowsley 1982-1986



Age Group 1-14

Figure : 7.6.4

Most Common Causes Of Death
Age Group - Knowsley 1982-1986

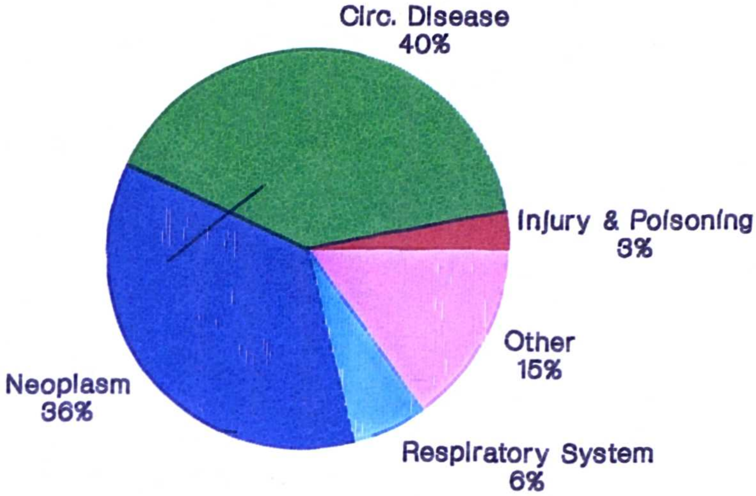


Source: St.Helens & Knowsley Health Authority, 1988

Age Group 15-34

Figure : 7.6.5

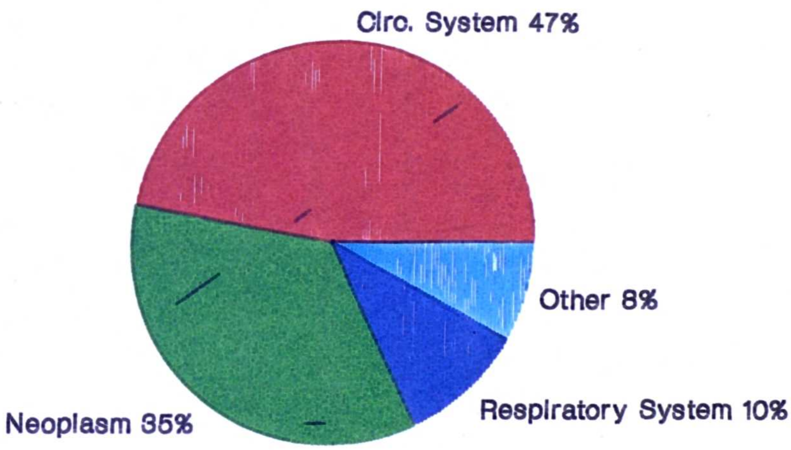
Most Common Causes Of Death
Age Group - Knowsley 1982-1986



Age Group 35-54

Figure: 7.6.6

Most Common Causes Of Death
Age Group - Knowsley 1982-1986



Age Grop 55-69

Source: St. Helens & Knowsley Health Authority , 1988

Figure : 7.6.7

by gender were very similar as shown by Tables 7.6.4 and 7.6.5

Table 7.6.4
Most common cause of death and age group
Knowsley Metropolitan Borough 1982-1986 *

Age group	Cause of death	Percentage	No of deaths in 5 years	Total deaths
1-9	Injury & Poisoning	36	22	61
	Infectious diseases	15	9	
	Endocrine and metabolic	11	7	
	Other	38	23	
10-14	Injury & Poisoning	46	6	13
	Neoplasm	23	3	
	Nervous system	23	3	
	Other	8	1	
15-24	Injury & Poisoning	51	39	76
	Circ. system	13	10	
	Nervous system	10.5	8	
	Other	25.5	19	
25-34	Neoplasms	30.5	27	89
	Injury & Poisoning	20	18	
	Circ. system	9	8	
	Other	40.5	36	
35-44	Circ. disease	38	63	167
	Neoplasm	33	55	
	Injury & Poisoning	13	22	
	Other	16	27	
45-54	Circ. diseases	41	247	605
	Neoplasm	37	224	
	Respiratory system	7	41	
	Other	15	93	
55-69	Circ. system	47.5	1213	2556
	Neoplasm	35	897	
	Respiratory system	9.5	242	
	Other	8	204	

* The most common causes of death in each age group (Diseases contributing less than 10% are not included)

St. Helens & Knowsley Health Authority, 1988.

Table 7.6.5 Most common cause of death Knowsley Metropolitan Borough 1982-1986

Diseases	Males		Females	
	Total No in 5 years	%	Total No in 5 years	%
Circulatory disorders	1,857	45	1763	44
Neoplasm	1,146	28	979	25
Respiratory disorders	568	14	599	14

Source: St. Helens & Knowsley Health Authority, 1988.

f. Conclusion

In Knowsley Metropolitan District the total standard mortality ratio's (SMR) from all causes were significantly higher than the national average. Closer examination at the ward levels clearly shows that six Knowsley wards have statistically higher SMRs than either the other district or the national averages. Overall the number of people who can expect to achieve a life span of at least 75 years in Knowsley is much lower than the national level. The years of life lost by people dying before this age can be calculated to show an indication of the impact individual diseases have. An estimated average number of years of life lost per annum through premature death from certain diseases is shown in Figure 7.6.8 For both men and women the main causes of death in Knowsley over the last five

Estimated loss of life
Knowsley

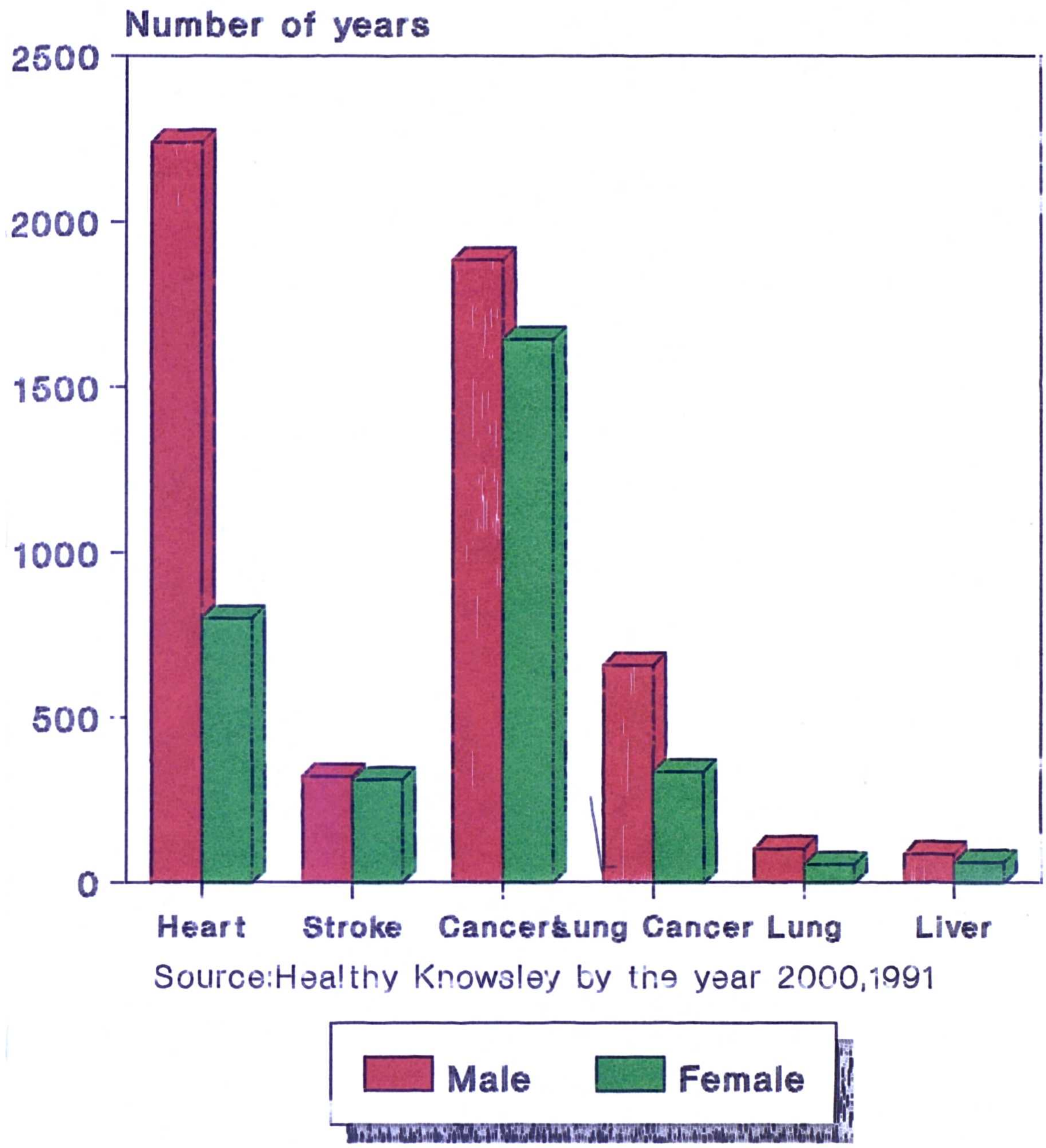


Figure : 7.6.8

years are circulatory diseases, neoplasms and respiratory diseases.

7.2.6 Disease

a. Circulatory Disease

In advanced countries, circulatory diseases account for approximately 50% of all death. The major contributing disease in Knowsley is ischaemic heart disease, which accounts for 60-70% of all circulatory deaths. Cerebrovascular diseases contribute about 20% of all deaths from circulatory diseases. International trends in this disease show marked differences between countries. Table 7.7.1 shows these differences in 1985.

Table 7.7.1 Standardised rates/100,000 for men & women aged 40-69 years

Northern Ireland	560
Scotland	545
Finland	530
Czechoslovakia	475
Ireland	460
England &Wales	430
New zealand	400
Sweden	330
USA	320
Japan	75

Source: St. Helens & Knowsley Health Authority, 1988.

There are marked regional variations in England and Wales, the North generally has higher rates than the South

East. See Table 7.7.2.

Table 7.7.2 Standardised mortality ratios for Coronary heart disease for men and women in the standard UK regions in 1986 (all ages)

Gender / Area	Men	Women
North West	117	116
North	116	124
Wales	111	106
West Midlands	103	104
South West	91	88
South East	89	87

Source: St. Helens & Knowsley Health Authority, 1988.

The mortality rates for men are highest for those over 65 years. The SMR's for ischaemic heart disease in Knowsley were 115 for male and 119 for female, in 1975-1984. The SMR for men in Knowsley has risen comparatively more. The SMR for women in that area has also risen. If the national death rate for the period 1975- 1984 is applied to the population of Knowsley for comparison, the following are the excess deaths experienced in the ten year period. See table 7.7.3.

Table 7.7.3 Excess death due to ischaemic heart disease (IHD) in Knowsley 1975- 1984.

Age \ Sex	Men	Women	Total
33 - 44	23	11	34
45 - 54	93	47	140
55 - 64	110	87	199
65 - 74	113	137	250
Total	339	284	623

Source: St. Helents & Knowsley Health Authority, 1988.

The age specific death rates for ischaemic heart disease for Knowsley Metropolitan Borough at ward level in 1983-1985 are shown in table 7.7.4.

Table 7.7.4 Death due to ischaemic heart disease in wards 1982-1985 Knowsley Metropolitan Borough.

Wards	SMR.
Kirkby central	144
Whiston North	141
St Gabriel's	140
Whitefield	138
Prescot East	137
Longview	135
Cherryfield	128
Northwood	123
Prescot West	123
St Michael's	120
Halewood west	120
Tower Hill	120
Halewood South	116
Park	111
Knowsley park	102
Princess	97
Hallewood East	95
Swanside	94
Cantril Farm	90
Roby	89
Whiston South	85

Source: St. Helents & Knowsley Health Authority, 1988.

The ward mortality pattern for ischaemic heart disease is not clear cut. Statistical evidence suggests that the six Knowsley wards have a high SMR which merits investigation and particulary in the Kirkby Central and Whitefield wards, where deaths in institutions are not a factor.

b. Cancer

The second most common cause of death in Knowsley is neoplasm. For men and women lung cancer makes the highest contribution, lung cancer is the commonest cause of death from neoplasm (22%) and for women breast cancer is second (17%). Colonic cancer ranks third (6%-7%).

c. Lung cancer

In England and Wales, the lung cancer rate is 1.1 deaths/thousand males and 0.3/thousand females per year. In Knowsley, it is the commonest cause of cancer death in females, a much higher proportion than in England and Wales. The major contributory factor in the causation of lung cancer is smoking. Other causes include occupational and environmental hazards, such as asbestos, radon, some metals, including cadmium , and certain organic chemicals such as polycyclic aromatic hydrocarbons, and atmospheric pollution by fossil fuels. The SMRs for lung cancer in Knowsley for males are 159 and females 95. The SMRs show no consistent change for males and females, being highest in 1977 and 1982. By applying the national rates to the Knowsley population, by age and sex groups, the excess number of deaths in Knowsley can be estimated, see Table 7.7.5.

Table 7.7.5 Excess death due to lung cancer in Knowsley in 1975-1984

Gender / Age	Men	Women	Total
33 - 44	9	3	12
45 - 54	53	33	86
55 - 64	129	51	180
65 - 74	142	31	173
Total	333	119	452

Source: St Helens & Knowsley Health Authority, 1988.

The SMRs in different age groups for men in Knowsley are the highest in the group 45-54 years. In Knowsley women, the SMRs for the age groups 45 - 54 and 55 - 64 are extremely high, especially in the age group 45 - 54 where it is more than twice the national level. Table 7.7.6 shows lung cancer for wards in Knowsley.

Table 7.7.6 S.M.R. for lung cancer 1983-1985 Knowsley

Wards	S.M.R.
St Gabriel's	189
Longview	176
Halewood West	176
Northwood	172
Cherryfield	167
Princess	162
Prescot East	160
Tower Hill	155
Halewood South	146
Cantril Farm	145
Park	142
Roby	133
Kirkby Central	127
Whiston North	127
St Michael's	124
Knowsley Park	123
Prescot West	117
Whitefield	115
Swanside	115
Halewood East	111
Page Moss	109
Whiston South	88

Source: St. Helens & Knowsley Health Authority, 1988.

Cancer of the stomach and colon are the second most common causes of death from cancer in Knowsley. It is more common in men and in members of low socio-economic groups, the incidence increases with age. In Knowsley, in men and women the majority of deaths from stomach cancer are in people over 65 year of age. Investigation of the distribution of stomach cancer in this and neighbouring boroughs has revealed no obvious geographical distribution which would match the known industrial hazards from chemicals involved in the fertiliser industry.

d. Respiratory disease

The third most common cause of death in Knowsley Metropolitan District is respiratory disease. 80-90% of all respiratory deaths are due to pneumonia and chronic obstructive airways disease. In this Borough, the pattern is slightly different. 60 - 65% of respiratory deaths in males are due to chronic obstructive airways disease. The SMRs between 1983 - 1985 at ward level are given in table 7.7.7.

Table 7.7.7 SMR for respiratory diseases 1983-1985 Knowsley

Wards	SMR.
Halewood South	258
Whiston North	191
St Gabriel's	175
Kirkby Central	165
Roby	162
Park	157
Princess	156
Halewood West	142
St Michael's	126
Prescot East	126
Prescot West	126
Knowsley Park	124
Northwood	127
Page Moss	107
Tower Hill	105
Longview	102
Cherryfield	98
Whitefield	98
Cantril Farm	96
Whiston South	95
Swanside	89
Halewood East	64

Source: St. Helens & Knowsley Health Authority, 1988.

In Knowsley over a quarter of wards have statistically high SMRs. Kirkby central appears again in the top five wards. Several wards in the southern and central part of Knowsley have unexpectedly high SMRs too.

7.3 Survey

7.3.1 Survey design

The most appropriate method for studying attitudes on a large scale is the sample survey, therefore, this study consisted of obtaining information by this method. There are different ways of gathering data on people's attitudes; observation, interviews, group discussions or filling in questionnaires. These questionnaires can be sent through the post or filled in on the spot; they may contain "open" questions where respondents have to answer in their own words or questions with multiple choice answers. Interviews may contain special questions; they are usually structured around certain topics; but sometimes have no definite structure.

I believe every method has its advantages and disadvantages and of course my aim was to prepare the most reliable and most adequate survey of local perception in

Kirkby and Ahwaz to hospital incineration. Observation of the site was carried out although a heavy local accent in Kirkby made group discussions impractical. Finally, taking part in the Public Inquiry was very useful.

I decided to use questionnaires with multiple choice answers, a method which gives an effective feeling of the range and depth of people's perception, and it facilitates the inputting of large amounts of data into the computer. Supplementary information of various kinds was also collected during the course of the study, including material on:

1- Demographic, historical and other characteristics of Kirkby and Ahwaz.
2- The health situation in Kirkby and Ahwaz.

A pilot survey was first carried out in Kirkby and on the basis of this, a questionnaire was designed to ask Kirkby residents about various aspects of their perception towards a hospital incinerator (see appendix 1). A survey also was conducted through resident interviews in October 1990 in Kirkby.

The survey focused on determining the fear of residents in relation to the proposed a hospital incinerator. It is hypothesised that there are perhaps four main reasons why residents near the proposed hospital incinerator are concerned :

Hypothesis 1: There is significant relationship between risk perception and attitude toward residential distance from hospital incinerator.

Hypothesis 2: There is a significant relationship between risk perception and age.

Hypothesis 3: There is a significant relationship between risk perception and sex.

Hypothesis 4: There is a significant relationship between risk perception and education.

7.3.2 Survey findings

Chapter one showed that the background literature does not demonstrate a positive attitude to neighbouring incinerators, see Sigler, 1973; Howe et al., 1988. I distributed 750 questionnaires to local people at Kirkby, chosen in two ways. Firstly, 500 questionnaire were distributed by members of a centre for the unemployed in Kirkby in 1990, and I received 148 completed questionnaires. Secondly I sent 250 questionnaires by mail to some organisation in Kirkby (Churches and Schools), unfortunately I received only 19 replies. Therefore I have received in total 167 questionnaires from Kirkby.

a. Age:

The first question of the survey asked people about their age. 167 people responded. The largest percentage of respondents (22.8 %) were between 56-65 years old. The lowest percentage of respondents (13.2%) were under 25 years. (For more information see figure 7.8.1)

b. Sex:

To this question 166 people responded, 60.2% were women and 39.8% were men.

c. Education:

For this question 10.8% of respondents were missing. The response to this question showed that 18.6% had only primary education, 43.7% completed only secondary education, 18% took higher education, 9% completed University courses.

d. Public concern over community problems

After these general questions the first question of the study asked people how often they were concerned about seven problems. For crime 53.3% said very often, 19.8%

said from time to time, 10.8% not much at all and 1.8% said, I don't know while 28.1% were very often concerned about accidents, 52.1% were very often concerned about smoking, 22.8% were very often concerned about industrial pollution risk, 57.5% were very often concerned about hospital incineration and 50.3% very often concerned about traffic. For details see Table 7.8.1 and Figure 7.8.2.

Table 7.8.1 Community problems

Level of perception Problem	Very often %	Time to time %	Not much at all %	Don't know %	Missing %
Crime	53.3	19.8	10.8	1.8	14.4
Accident	28.1	29.3	14.4	0.6	27.5
Smoking	52.1	15.6	8.4	0	24.0
Risk at work	22.8	19.2	16.2	6.6	35.3
Industrial pollution	53.3	18.6	7.2	3.6	17.4
Hospital incinerator	57.5	11.4	12.6	4.8	13.8
Traffic	50.3	13.8	12.6	4.8	18.6

e. project awareness and risk perception

The second question, of the questionnaire asked, "are you aware of this project?" According to the respondents 80.8% knew that there was a project for Kirkby but 5.4% of respondents did not respond to this question. The response indicated that 40.7% got the information about it through newspapers, 34.7% through friends, 19.8% through leaflets,

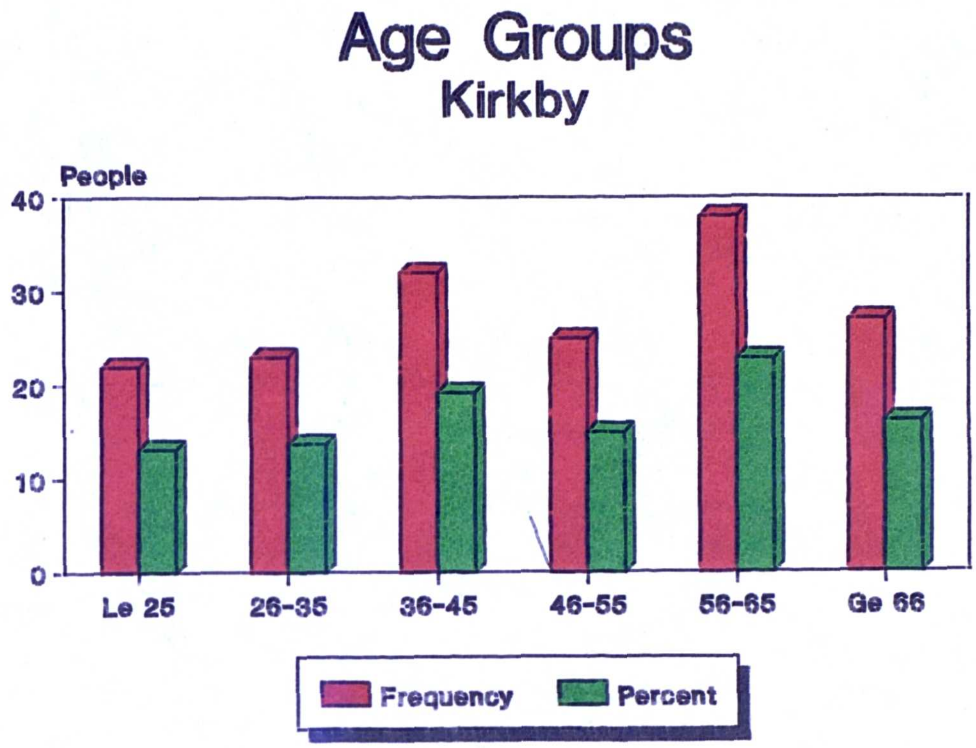


Figure 7.8.1

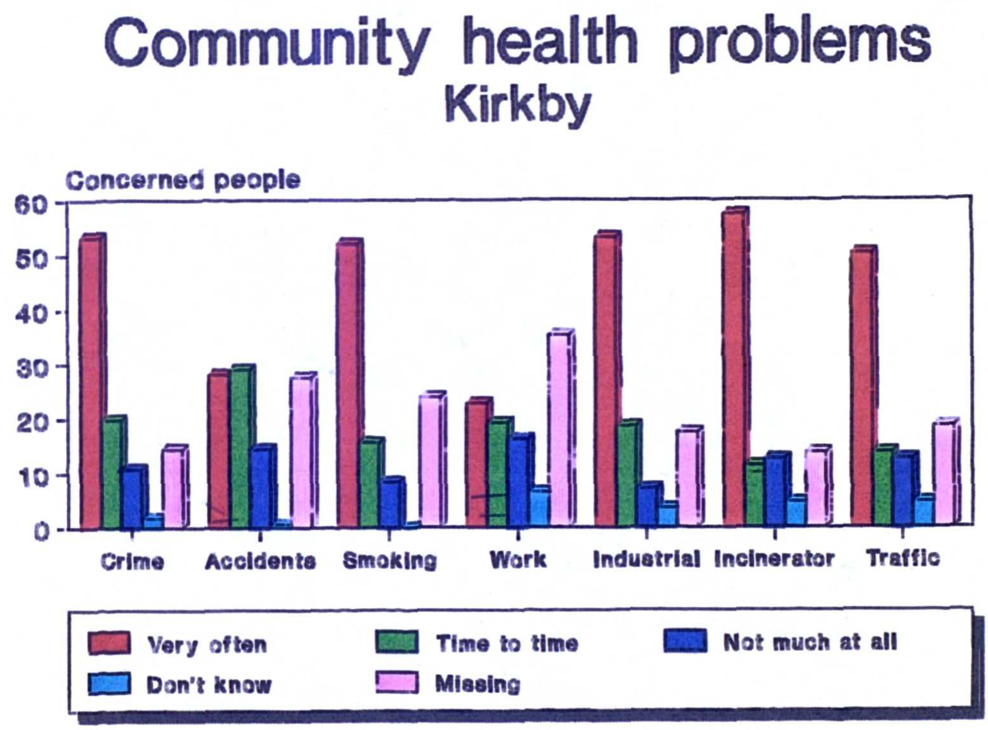


Figure 7.8.2

14.4% through TV and 5.3% heard about it in other ways.

The hospital incinerator might cause many problems(see Gatrell and Lovett, 1992) for example fire, explosion water pollution, soil contamination, smell, noise, air pollution, hazards from big lorries. For 3rd question 77.2% respondent were believe air pollution is very serious risk than other problems. Table 7.8.2 and Figure 7.8.3 shows the result from the respondents to question 3.

Table 7.8.2 Risk from hospital incinerator

Level of risk / Problems	Very serio-us risk	Moderate risk	Not serious risk	Do not know	Miss-ing	Total
Fire	38.3%	12.6%	11.4%	1.2%	36.5%	100%
Explosion	35.9%	11.4%	13.2%	0.6%	38.8%	100%
Water Pollution	58.1%	8.4%	7.8%	1.8%	24%	100%
Soil contamination	51.5%	15%	4.8%	1.2%	27.5%	100%
Smell	59.9%	12%	4.8%	0.6%	22.8%	100%
Noise risk	38.9%	18%	6%	4.2%	32.9%	100%
Air Pollution	77.2%	%9	1.2%	2.4%	10.2%	100%
Hazardous from big lorries	43.1%	14.4%	5.4%	4.2%	32.9%	100%
Other risk	4.8%	6%	1.2%	5.4%	82.6%	100%

<u>f. Public concern over health problems</u>

29.9% respondents to the fourth question felt very seriously that they had had some trouble about their general health. According to the responses 24% were very seriously concerned about eye irritation. Respiratory problems were a very serious concern to 33.5%. Tension concerned 20.4%, and skin irritation, rashes or spots were experienced by 27.5% very seriously. For more information see Table 7.8.3 and Figure 7.8.4.

Table 7.8.3 Health problems

Level of risk / Problem	Very serio-us	Moderate concern	Not seri-ous	Do not know	Miss-ing	Total
General health	29.9%	29.9%	13.8%	4.2%	22.8	100%
Eye irritation	24%	19.2%	18%	7%	31.7%	100%
Tension	20.4%	13.8%	21.6%	5.4%	38.9%	100%
Respiratory symptoms	33.5%	13.8%	24%	4.2%	24.6%	100%
Skin irritation	27.5%	16.2%	19.2%	3.6%	33.5%	100%

g. Possible problems from incinerator proximity

According to question 5, the hospital incinerator is a cause of concern to 85.6% of those living near it. Of these, 67.1% were very greatly concerned while 2.4% were not worried at all. These findings were supported by

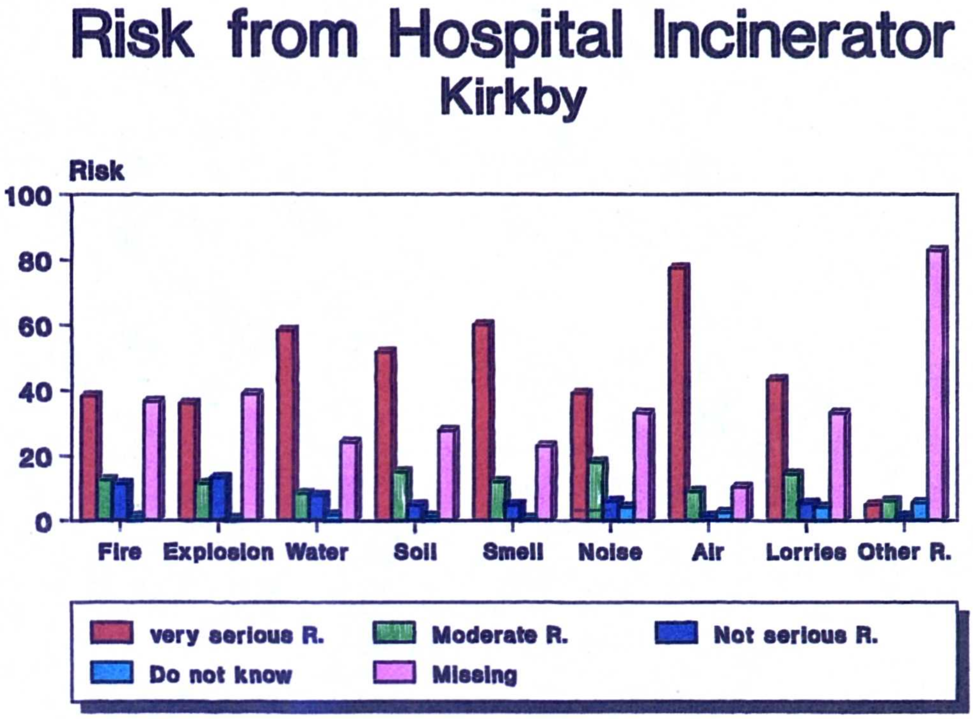


Figure 7.8.3

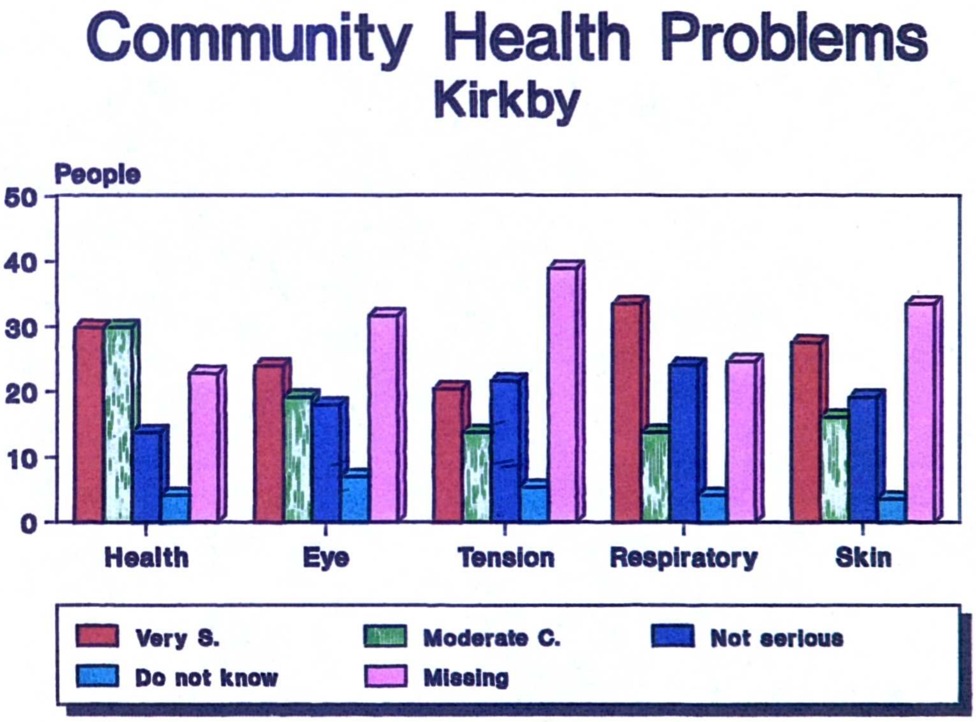


Figure 7.8.4

answers to questions 7, 10 and 11. A sizeable population (Question 7), 86.2% is opposed to the idea that a hospital incinerator should be installed close to their residence.

For example if a hospital incinerator is to be installed close to their area, 69.5% would move away but 28.1% would not move away (Question 10). Also the most suitable site to install a hospital incinerator should be very far from their house according to 71.9% and far according to 9.6% (Question 11).

h. Possible problems from factories

Question 6 referred to the effect of factories on the community. 32.9% were concerned about the effects of these emissions from factories on the health of aged people. 34.7% had no knowledge about the effect of such emissions on pregnant women. Knowledge about the effects of emissions from factory chimneys on child health was well know to 37.7% and 25.7% of respondents knew about the effect of these emission from factories on crops. 22.8% thought the emissions caused a serious problem to the health of animals. 55.7% have a firm belief that industries cause damage to the environment. Finally, 66.5% were ignorant about the other effects of these emissions from factories. See Table 7.8.4 and Figure 7.8.5.

Table 7.8.4 Possible problems from factories.

Level of risk / Case	Very serious problem	Mode-rate problem	Slight problem serious	Not serious problem	Do not know	Miss-ing
Elderly people	32.9	12.6	10.2	13.2	3.6	27.5
Pregnant women	34.7	9.0	11.4	9.6	3.0	32.3
Children	37.7	7.8	13.2	10.8	2.4	28.1
Crops	25.7	6.6	8.4	16.2	3.0	40.1
Animals	22.8	11.4	7.2	11.4	6.0	41.3
Environ-mental pollution	55.7	11.4	6.0	7.4	2.4	16.2
Other	9.6	3.6	7.2	7.8	5.4	66.5

i. Possible problems from a hospital incinerator.

Though the effect of emissions from hospital incinerator chimneys upon elderly people are known to be a very serious problem to 57.5%, 3% are completely ignorant about this aspect. Living in the vicinity of a hospital incinerator is a very serious problem for pregnant women according to 59.9%. A sizeable number, 61.1% of respondents, know about the effects of emissions from a hospital incinerator's chimney on children. The response indicates that 51.5% of people believe a very serious problem will be caused to crops. The effects on animals were well know to 50.3%. Surprisingly, 71.9% believe that hospital incinerators are a very serious problem to the environment. 67.1% are ignorant about the other effects of these emissions. Table 7.8.5 and Figure 7.8.6 show these responses.

Table 7.8.5 Hospital incinerator problems

Level of risk . Case	Very serious problem	Mode -rate problem	Slight problem serious	Not serious problem	Do not know	Miss -ing
Elderly people	57.5	10.8	8.4	4.2	3.0	16.2
pregnant women	59.9	9.0	7.2	3.0	2.4	18.6
Children	61.1	9.6	3.0	3.6	2.4	20.4
Crops	51.5	6.6	4.2	6.6	4.2	26.9
Animals	50.3	4.8	3.6	4.8	6.0	30.5
Environ -mental pollution	71.9	4.2	4.2	0	1.8	18.0
Others	19.8	6.0	1.8	0.6	4.8	67.1

j. Other considerations.

The response (Question 8) indicates that 67.7% of people would participate in any action against the installation of a hospital incinerator. Results from

Possible Problems from Factories
Kirkby

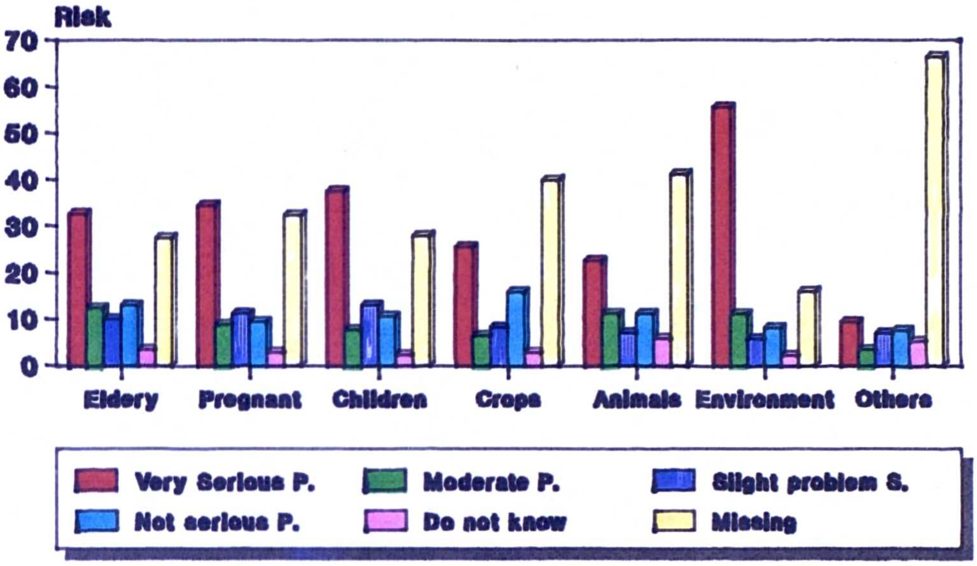


Figure 7.8.5

Hospital Incinerator Problems
Kirkby

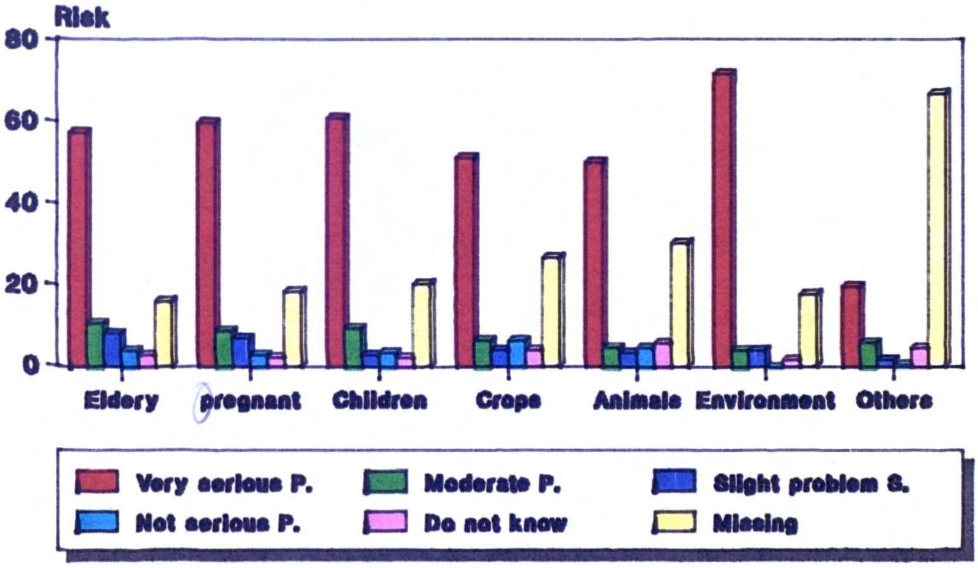


Figure 7.8.6

question 9 shows 62.9% believe that would bring no advantages while 18 % agreed it would allow the disposal of hospital waste in a healthy way.

k. Discussion

Tables 7.9.1 and 7.9.2 show the data related to cross tabulation of participants residential distance and their risk perception.

Table 7.9.1 Kirkby- Residential distance and risk perception.

V65 HOW FAR AWAY SHOULD THE INCINERATOR BE

by V63 ARE YOU CONCERNED ABOUT LIVING NEAR AN INCINERATOR

V 63 Exp Val Residual V 65	Yes	No	Missing	Row Total
Far	14.6 -.6	1.3 1.7	1.1 -1.1	17 10.2%
Very far	102.8 9.2	9.3 -7.3	7.9 -1.9	120 71.9%
Do not know	24.0 -9.0	2.2 5.8	1.8 3.2	28 16.8%
Missing	1.7 .3	.2 -.2	.1 -.1	2 1.2%
Column Total	143 85.6%	13 7.8%	11 6.6%	167 100.0%

As the data of table 7.9.1 above, indicate the closer the people live to the hospital the more concerned they seem to be and vice versa. The results of the Chi-square analyses on the differences among their risk perception showed that the residuals of the obtained frequencies and the expected frequencies in each cell are statistically significant [K = 34.96 , df = 6 , P = 0.0000].

Table 7.9.2 Kirkby- Desire to move and risk perception

V64 HOW MUCH ARE YOU CONCERNED ABOUT HOSPITAL

by V51 MOVE AWAY IF A INCINERATOR IS TO BE CLOSE

V 51 Exp Val Residual V 64	Yes	No	Missing	Row Total
Very great	77.8 16.2	31.5 -15.5	2.7 -.7	112 67.1%
Moderate	15.3 -4.3	6.2 3.8	.5 .5	22 13.2%
Slight	2.8 -2.8	1.1 2.9	.1 -.1	4 2.4%
Not at all	2.8 -.8	1.1 .9	.1 -.1	4 2.4%
Missing	17.4 -8.4	7.0 8.0	.6 .4	25 15.0%
Column Total	116 -8.4	47 28.1%	4 2.4%	167 100.0%

Also the results (table 7.9.2) of the Chi-square analyses on the obtained differences among their risk perception showed that the residuals of the obtained frequencies and the expected frequencies in each cell are statistically significant [K = 39.67, df = 8, P = 0.0000] These results, therefore, support the existing association between the dependent variable and independent variable.

To sum up, the above data clearly indicate that the obtained data in the above tables are quite supportive of the prediction made in hypothesis 1 which assumed a significant association between residential distance from the hospital and the risk perception towards hospital incinerator. The finding of this study is consistent with both Chi-square.Turning now to the age variable, Tables 7.9.3 and 7.9.4 show the cross tabulation of the data related to the age of the participants and their risk perception.

Table 7.9.3 Kirkby- Age and risk perception.

V 63 ARE YOU CONCERNED ABOUT LIVING NEAR A HOSPITAL INCINERATOR

Age Exp Val Residual V 63	Le 25	26-35	36-45	46-55	56-65	Ge 66	Row total
Yes	18.8 -5.8	19.7 -3.7	27.4 2.6	21.4 1.6	32.5 3.5	23.1 1.9	143 85.6 %
No	1.7 4.3	1.8 2.2	2.5 -1.5	1.9 .1	3.0 -3.0	2.1 -2.1	13 7.8%
Missing	1.4 1.6	1.5 1.5	2.1 -1.1	1.6 -1.6	2.5 -.5	1.8 .2	11 6.6%
Total	22 13.2 %	23 13.8 %	32 19.2 %	25 15.0 %	38 22.8 %	27 16.2 %	167 100.0 %

Table 7.9.4 Kirkby- Age and detailed risk perception

Age Exp Val Residual V 64	Le 25	26- 35	36-45	46-55	56-65	ge 66	Row Total
Very great	14.8 -7.8	15.4 -4.4	21.5 -.5	16.8 3.2	25.5 8.5	18.1 .9	112 67.1 %
Moderate	2.9 4.1	3.0 2.0	4.2 2.8	3.3 -.3	5.0 -5.0	3.6 -3.6	22 13.2 %
Slight	.5 .5	.6 .4	.8 -.8	.6 -.6	.9 .1	.6 .4	4 2.4%
Not at all	.5 -.5	.6 -.6	.8 -.8	.6 -.6	.9 .1	.6 2.4	4 2.4%
Total	22 13.2 %	23 13.8 %	32 19.2%	25 15.0%	38 22.8%	27 16.2%	167 100.0 %

As table 7.9.3 and 7.9.4 show, the older the people the more concerned they are. The results of the Chi-square analyses indicated that the obtained residuals in each cell between the obtained and expected frequencies are quite significant [K = 28.27, df = 10, P =.oo16] These results are there fore consistent with the assumption made in hypothesis 2 which predicted "There is a significant relationship between risk perception and age" the these findings support hypothesis two. Also results from Table 4 [K= 49.15, df = 20, P =.0002] support this hypothesis.

For the sex variable, Tables 7.9.5 and 7.9.6 show the cross tabulation of the data related to sex of the participants and their risk perception

Table 7.9.5 Kirkby- Sex and risk perception

Sex Exp Val Residual V 63	Male	Female	Missing	Row Total
Yes	56.5 -2.5	85.6 2.4	.9 .1	143 85.6%
No	5.1 2.9	7.8 -2.8	.1 -.1	13 7.8%
Missing	4.3 -.3	6.6 .4	.1 -.1	11 6.6%
Total	66 39.5%	100 59.9%	1 .6%	167 100.0%

Table 7.9.6 Kirkby- Sex and detailed risk perception

V64 HOW MUCH ARE YOU CONCERNED ABOUT HOSPITAL INCINERATOR

Sex Exp val Residual V 64	Male	Female	Missing	Row Total
Very great	44.3 -9.3	67.1 8.9	.7 .3	112 67.1%
Moderate	8.7 4.3	13.2 -4.2	.1 -.1	22 13.2%
Slight	1.6 .4	2.4 -.4	.0 .0	4 2.4%
Not at all	1.6 2.4	2.4 -2.4	.0 .0	4 2.4%
Missing	9.9 2.1	15.0 -2.0	.1 -.1	25 15.0%
Total	66 39.9%	100 59.9%	1 .6%	167 100.0%

As Tables 7.9.5 and 7.9.6 show, when the respondents generally attitude were asked in yes/no conditions, the results showed that there was no significant relationship between risk perception and sex

[K= 3.34, df = 2, P = 0.187] but when the question was asked in a more detailed manner, we can see that the results [K= 12.85, df= 3,

P= 0.004] are supportive of the assumption made in hypothesis 3.

Turning now to the education variable, Tables 7.9.7 and 7.9.8 show the cross tabulation of the data related to age of the participants and their risk perception of a hospital waste incinerator.

Table 7.9.7 Kirkby- Education and risk perception

Education Exp Val Residual V 63	Prima-ry	Seco-ndary	Higher Educat-ion	Unive-rsity	Miss-ing	Row Total
Yes	26.5 1.5	62.5 2.5	25.7 -3.7	12.8 .2	15.4 -.4	143 85.6%
No	2.4 -1.4	5.7 -4.7	2.3 5.7	1.2 .8	1.4 -.4	13 7.8%
Missing	2.0 .0	4.8 2.2	2.0 -2.0	1.0 -1.0	1.2 .8	11 6.6%
Total	31 18.6%	73 43.7%	30 18.0%	15 9.0%	18 10.8%	167 100.0 %

Table 7.9.8 Kirkby- Education and detailed risk perception

Education Exp val Residual V 64	Prima- ry	Secon- dary	Higher Educat- ion	Univer- sity	Miss- ing	Row Total
Very great	20.8 4.2	49.0 5.0	20.1 -5.1	10.1 -3.1	12.1 -1.1	112 67.1%
Moderate	4.1 -3.1	9.6 -1.6	4.0 3.0	2.0 4.0	2.4 -2.4	22 13.2%
Slight	.7 -.7	1.7 1.3	.7 -.7	.4 -.4	.4 .6	4 2.4%
Not at all	.7 1.3	1.7 .3	.7 -.7	.4 -.4	.4 -.4	4 2.4%
Missing	4.6 -1.6	10.9 -4.9	4.5 3.5	2.2 -.2	2.7 3.3	25 15.0%
Total	31 18.6%	73 43.7%	30 18.0%	15 9.0%	18 10.8%	167 100.0 %

As the data of the above tables 7.9.7 and 7.9.8 indicate the people who were educated more than others, were more concerned, and vice versa.The results of the Chi-square analyses on the obtained differences among their risk perception showed that the residuals of the obtained frequencies and the expected frequencies in each cell are statistically significant.

CHAPTER EIGHT

CASE STUDY 2 AHWAZ, IRAN

8.1 Introduction

This chapter presents the findings of a second social survey. It was carried out in Ahwaz, Iran in August and September 1991, and examined local perceptions towards a hospital incinerator plant in that area. To be able to visit four hospitals (Kolestan, Emam Khomeini, Razi, Sina) and do my research legally, I had to have permission from the Chancellor of the Medical Science University. For that reason I wrote a letter to him explaining my work and research. After writing this letter, I had a chance to see Dr Alavi (Chancellor of the Medical Science University) himself. In my discussions with Dr Alavi I explained to him my finding on peoples attitudes and perceptions towards hospital incinerators.

Dr Alavi provided me with a letter of permission to do my research with the help of the hospital management staff. For that reason I had the help of two social services staff from each hospital to assist me. I also explained to the social services staff about my work, the hospital incinerator, and the attitudes of people who live near hospital incinerators.

At random I chose 200 households from each area around the hospitals. The social service staff used this list and in case any of the households were not available to answer the questionnaires they could pass it to the next-door neighbour. To get more detailed results we also had more detailed interviews with some households. Every member of staff had 100 questionnaires to give to households.

However at the end it became apparent that unfortunately we had some questionnaires missing. Finally, it must be explained that in every house only one person completed a questionnaire.

This chapter is divided into two main sections. The first discusses the background and health of Iran. The second presents the results of a survey in four communities around four hospitals in Ahwaz and discusses them.

8.2 Background and health

8.2.1 General information about Islamic Republic of Iran

a. Location (geographical perspective)

Iran is a country in the Middle East creating the Western part of Asia and is situated between 44° and 64° longitude and 25° and 40° latitude. The map, Figure 8.2.1 shows the shape of Iran. The Islamic Republic of Iran has a surface area of 1,648,000 square Km. (Iran is about equal to the area of Great Britain, France, Spain and Germany put together). It is the fourth largest country in Asia. Iran

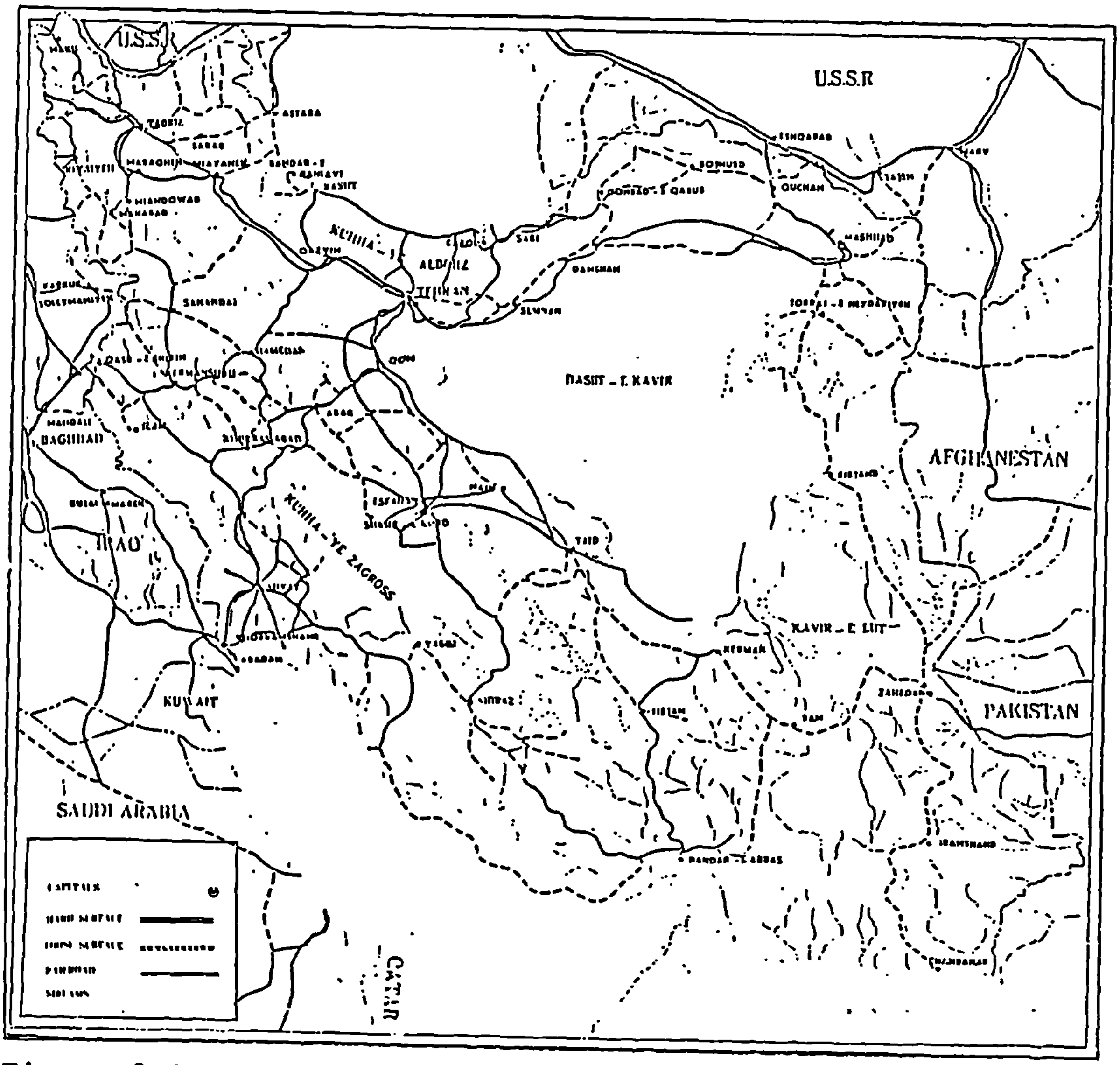


Figure 8.2.1 Map of Iran

Source: Ministry Information and Tourism is bounded on the north by the Transcaucasus, Azarbijan and the Caspian Sea, on the West by Iraq and Turkey, in the South by the Persian Gulf and the Sea of Oman and in the East by Afghanistan and Pakistan. Iran has 24 administrative Provinces, 218 districts, 595 subdistricts and approximately 69,700 villages.

b. History

Iranian history presents a rich complex of mythology, legend, recorded fact and living tradition. Iran means, the land of the Aryans. "The oldest known civilization in Iran is that of Elam, which has been the subject of a great deal of research by scholars. Elam was a small kingdom which came into being around the 10th century BC, in the fertile plain between the rivers Karun and Karkheh in what is now the South-Western Province of Khuzestan" (Ministry of Information and Tourism, 1974).

c. Population

A 1956 census reported that the population of Iran was 18,954,000. According to the 1966 census, out of a total population of 25,789,000 about 60% (some 15,400,000) were under 25, and 35% (about 8,750,000) were between 25 and 65, while less than 5% (about 970,000) were 65 year old. The birth rate was 43 per 1,000 while the death rate was about

14 per 1,000. The census in 1976 reported a total population of 33,600.000. The last census in 1986, reported a total population of about 50 million. However, in 1984 the population was estimated to be about 47 million. According to the survey carried out by the Ministry of Health during 1985-1986 the natural increase of population has been estimated to be 3.4 percent (34 per 1000). If this rate is continued the total population would be about 80,000,000 by the year 2000.

There are an estimated 9.5 million families averaging about 5 persons per family. The median age is about 16, which means that 50 percent of the population is under 16 years of age.

Population densities vary widely across the country, between 7 and 313 people per Sq Km averaging 28.7 per Sq Km overall. Fifty four percent of the population live in the urban areas. The life expectancy at birth for women is 69, for men 66 and a total average of 67 years has been estimated. The religion of 98% of the population is Islam, and 96% of the Moslems are Shiias. There are also non-Moslem minorities including Christians, Jews and Zoroastrians, and a few with other religions or ideas.

8.2.2 Public health in Iran

Iran has approximately 600 hospitals with more than

70,000 beds; the minority of them have hospital incinerators. The National Health System in Iran includes both private and public health services, which are used side by side. Although the public sector is responsible for the provision of community health, there is nothing to prevent the use of the private sector by the people.

8.2.3 City of Ahwaz

Ahwaz is the oldest city in Khozestan province and its name is mentioned in Iranian earliest historical records. Hormoz Shaher was the historical name for Ahwaz in 226 BD. This was at the time of the Sasanian tribe.

In the first Islamic century Ahwaz was one of the most important and largest cities of Khozestan province. At the present time Ahwaz is the centre of Khozestan and is one the largest cities in Iran. The Karun River divides Ahwaz into two parts and is very beautiful.

Khozestan province's population is 2,702,533 people composed of 453,208 families. Ahwaz District's population is 884,528 people from 145,967 families. It's suburbs and dependants contain 589,529 people from 41,149 families. The Rural population is 294,999 people from 41,159 families.

At present Ahwaz City has twelve hospitals with all the facilities for different forms of treatment. Nine of these hospitals are run by the government and the rest are run by the private sector. There are in total 2,192 hospital beds in Ahwaz which means approximately one bed for 440 people. A Survey shows that 52% of Khozestan province's hospitals are in Ahwaz City.

According to the international classification the number of deaths in Khozestan province in 1991 was 6,476 people and 54% of these deaths happened in Ahwaz city. According to local statistics the highest cause of death, 23% of these cases (2,043), resulted from high blood pressure. This might be explained by the eight years Iran-Iraq war which took place in this province.

The University of Medical Science has made a contract with the Ahwaz City Council to put some of the waste from hospitals belonging to the University in landfills 40 Km away from Ahwaz. There is a daily delivery of waste to the site.

Generally the radioactive waste is collected separately and given to the atomic energy centre. No safety precautions are taken with the stored active waste.

Four hospitals were surveyed in Ahwaz, these were Kolestan, Emam khomeini, Razi and Sina. The University has a project to install a hospital incinerator for the hospitals belonging to the university. The incinerator of Kolestan Hospital is old, small and not sufficient for the hospital's needs. Also it was damaged in the war between Iran and Iraq. The incinerator of Emam Khomeini Hospital is out of order and the new one is not yet installed. In Razi Hospital, the previous incinerator is out of order and the new one is not ready yet. Sina hospital has a refinery for waste water; before entering the Karun River it has to pass through the refinery. Wastes from the general department and laboratories are burnt in an incinerator but unfortunately other wastes burn in the open which is very dangerous for patients and residents living near the hospital.

8.3 Survey findings

8.3.1 Survey findings from Kolestan Hospital

a. Age

The first question of the survey asked people about their age. No person was missing, therefore 146 people responded. The largest percentage of respondents (24%) were between 46 and 54 years old. The lowest percentage of respondents (4.8%) were 66 or more years old. See Figure 8.6.1.

b. Sex

Of 145 respondents, 77.4% were men and 21.9% were women.

c. Education

The response to this question showed that 7.5% were illiterate, 53.4% had only Primary Education (7-11 years old), 14.4% completed only Guidance Education (12-14 years old), 18.5% finished High School (15-18 years old) and 5.5% graduated from University.

d. Public concern over community problems

After these general questions the first question of the study asked people how often they were concerned about 7 problems. These were crime,accident, smoking, working, industrial pollution, hospital incinerator and traffic. Hospital incinerators concerned 47.9% very often, 43.2% from time to time, 6.2% not much at all and 2.7% don't know. Thirty point one percent were very often concerned about crime, 21.2% were very often concerned about accidents, 26% were very often concerned about smoking, 20.5% were concerned about risks at work, 12.3% were very often concerned about industrial pollution, and 32.2% were very often concerned about traffic. Table 8.6.1 and Figure 8.6.2 show these.

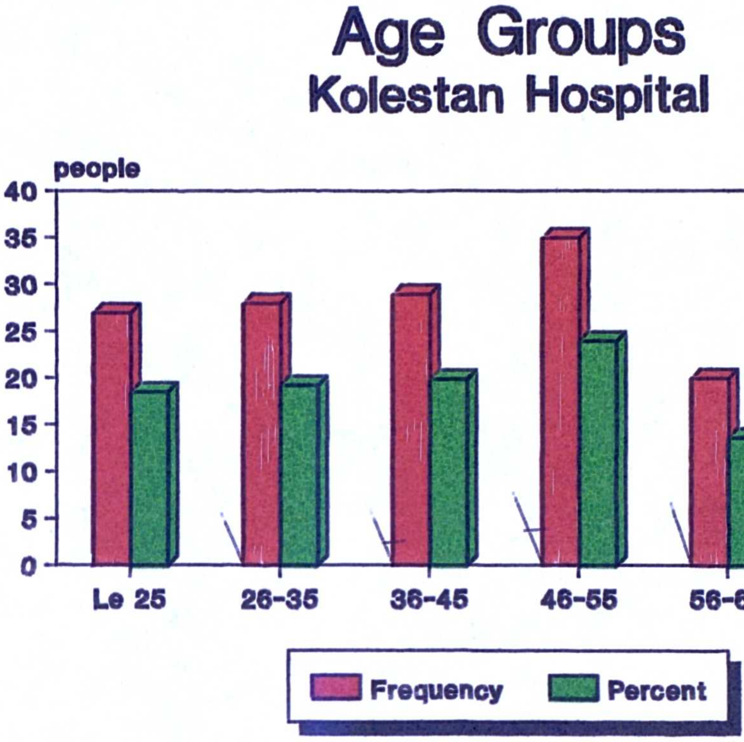


Figure 8.6.1

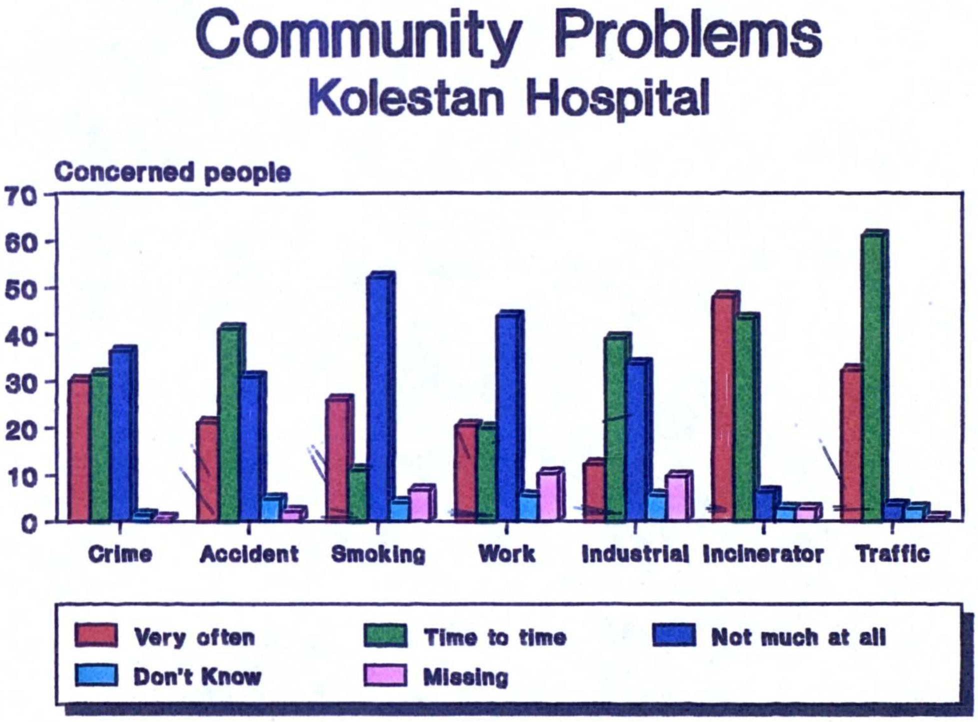


Figure 8.6.2

Table 8.6.1 Community problems

Level of perception Problem	Very often %	Time to time %	Not much at all %	Don't know %	Missing %
Crime	30.1	31.5	36.3	1.4	0.7
Accident	21.2	41.1	30.8	4.8	2.1
Smoking	26	11	52.1	4.1	6.8
Risk at work	20.5	19.9	43.8	5.5	10.3
Industrial pollution	12.3	39	33.6	5.5	9.6
Hospital incinerator	47.9	43.2	6.2	2.7	2.7
Traffic	32.2	61	3.4	2.7	0.7

e. Project awareness and risk perception

The second question, of the questionnaire asked, whether they were aware of this project? According to the respondents 27.4% knew that there was a project for Kolestan. 69.2% didn't know that there was a project for that area and 3.4% did not answer this question. The response indicated that 2.7% got the information about it through newspapers, 15.8% through friends, 0.7% through leaflets, nobody through TV and 4.8 % heard about it in other ways.

The third question referred to possible problems caused by the incineration. The largest number of respondents, 53.4% believed that fire was a very serious risk. Table 8.6.2 and Figure 8.6.3 show the results.

Table 8.6.2 Risk from hospital incinerator

Level of risk Problems	Very serious risk	Moderate risk	Not serious risk	Do not know	Miss-ing
Fire	53.4	41.8	-	2.7	2.1
Explosion	33.6	43.2	0.7	11.6	11
Water Pollution	30.1	32.9	3.4	17.1	16.4
Soil contamination	8.9	39	6.2	20.5	25.3
Smell	50	42.5	0.7	2.1	4.8
Noise risk	13.7	53.4	7.5	13.7	11.6
Air Pollution	38.4	47.9	6.8	6.8	-
Hazardous from big lorries	11.6	50.7	0.7	13.7	23.3
Other risk	2.1	2.7	6.2	50	39

f. Public concern over health problems

The fourth question referred to health concerns. 25.3% of respondents were very seriously concerned, 28.1% were moderately concerned, 39% were not seriously concerned about their general health. Sixteen percent were very seriously concerned about eye irritation. Respiratory problems were a very serious concern to 19.2%. Tension concerned 26.7% and skin irritation, rashes or spots were experienced by 13% very seriously. For further information see Table 8.6.3 and figure 8.6.4.

Table 8.6.3 Health problems.

Level of risk Problem	Very serious	Moderate concern	Not serious	Do not know	Missing
General health	25.3	28.1	39.9	1.4	6.2
Eye irritation	16.4	11.6	52.1	1.4	18.5
Tension	26.7	28.8	29.5	1.4	13.7
Respiratory symptoms	19.2	14.4	34.9	8.2	23.3
Skin irritation	13	9.6	41.8	4.1	31.5

g. Possible problems from incinerator proximity

According to question five, the hospital incinerator is a cause of concern to the 73.3% of those living near it. Of these 54.1% were very greatly concerned while 1.4% were not worried at all. These findings were strongly with answers to questions 7, 10 and 11. A sizeable population (Question 7) 97.3% is opposed to the idea that a hospital incinerator should be installed close to their homes. If a hospital incinerator is to be installed close to their area, 7.5% would move away but 88.4% would not move away (Question 10). The most suitable site to install a hospital incinerator should be very far from their house according to 70.5% and far according to 15.8% (Question 11).

h. Possible problems from factories

Question six referred to the effect of factories on the community. Fifty five point five percent were concerned

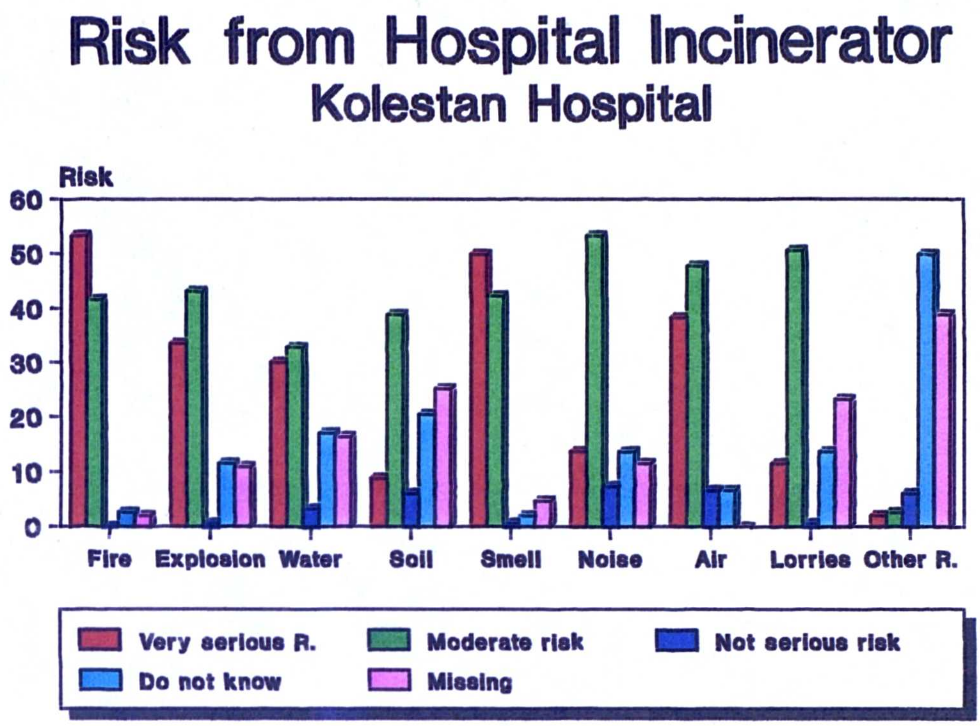


Figure 8.6.3

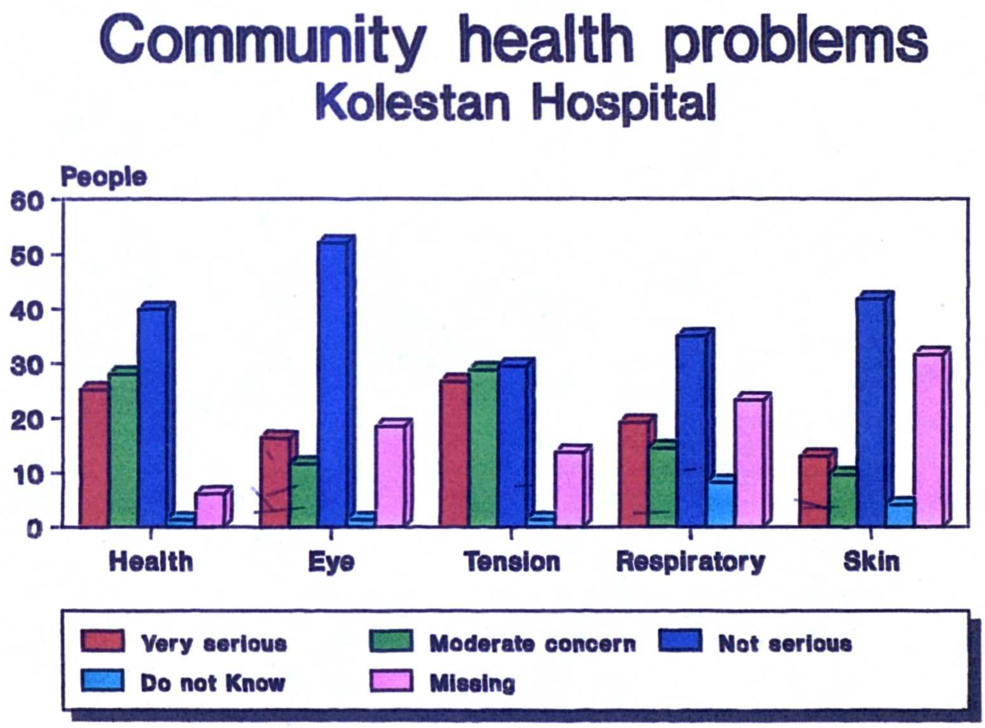


Figure 8.6.4

about the effects of these emissions from factories on the health of aged people. Forty five point two percent had no knowledge about the effect of such emissions on pregnant women. Knowledge about the effects of emissions from factory chimneys on child health was well know to 38.4% and 5.5% of respondent knew about the effect of these emissions from factories on crops. Fourteen point four percent thought the emissions caused a serious problem to the health of animals. Twenty one point two percent have a firm belief that industries cause damage to environment. Twenty six point seven were ignorant about the other effects of these emissions from factories. See Table 8.6.4 and Figure 8.6.5.

Table 8.6.4 Possible problems from factories.

Level of risk / Case	Very serious problem	Mode -rate problem	Slight problem serious	Not serious problem	Do not know	Miss-ing
Elderly people	55.5	35.6	2.7	0.7	2.7	2.7
Pregnant women	45.2	37	2.7	0.7	8.9	5.5
Children	38.4	34.9	6.2	1.4	11	8.2
Crops	5.5	25.3	24	13.7	18.5	13
Animals	14.4	32.9	18.5	14.4	11.6	8.2
Environ -mental pollution	21.2	43.8	11.6	4.8	7.5	11
Others	0.7	2.7	1.4	15.8	52.7	26.7

i. Possible problems from a hospital incinerator.

Though the effect of emissions from hospital incinerator chimneys (Question 12) upon elderly people are known to be a very serious problem to 63%, 4.8% are completely ignorant about this aspect. Living in the vicinity of a hospital incinerator is a very serious problem for pregnant women according to 52.7%. A sizeable number, 38.4% of respondents, know about the effects of emissions from a hospital incinerator's chimney on children. The response indicates that 6.8% of people believe very serious problems will be caused to crops. The effects on animals were well know to 9.6% of the respondents 19.2 % believed that hospital incinerators caused a very serious problem to the environment. Twenty seven point four percent are ignorant about the other effects of these emissions. Table 8.6.5 and Figure 8.6.6 show the results from these responses.

Table 8.6.5 Hospital incinerator problems.

Level of risk / Case	Very serious problem	Mode -rate problem	Slight problem serious	Not serious problem	Do not know	Miss-ing
Elderly people	63	29.5	0.7	-	2.1	4.8
Pregnant women	52.7	33.6	0.7	-	8.9	4.1
Children	38.4	33.6	4.8	2.1	11.6	9.6
Crops	6.8	26.7	28.1	9.6	14.4	14.4
Animals	9.6	40.4	21.2	8.2	9.6	11
Environ -mental pollution	19.2	42.5	13	4.8	9.6	11
Others	0.7	0.7	2.1	12.3	56.8	27.4

Possible Problems from Factories
Kolestan Hospital

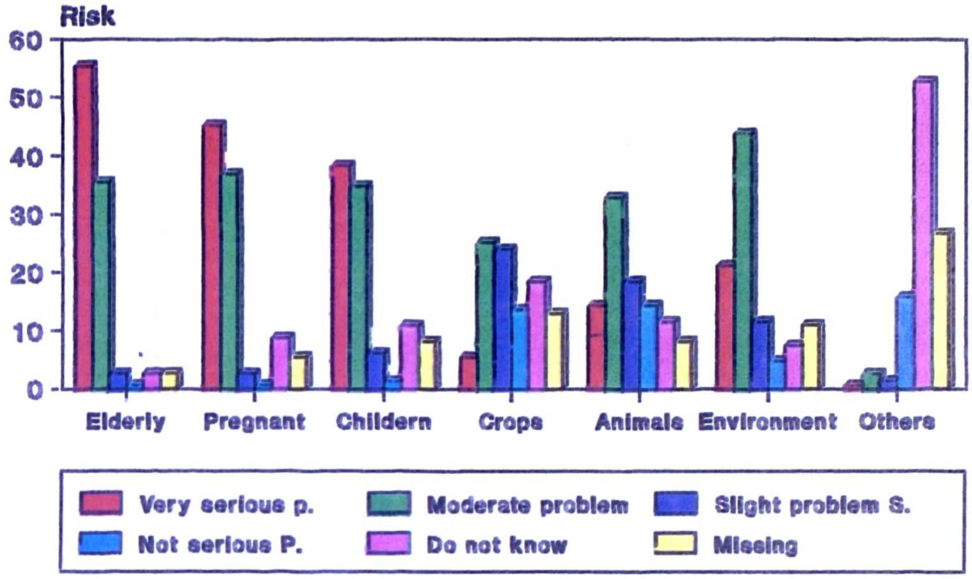
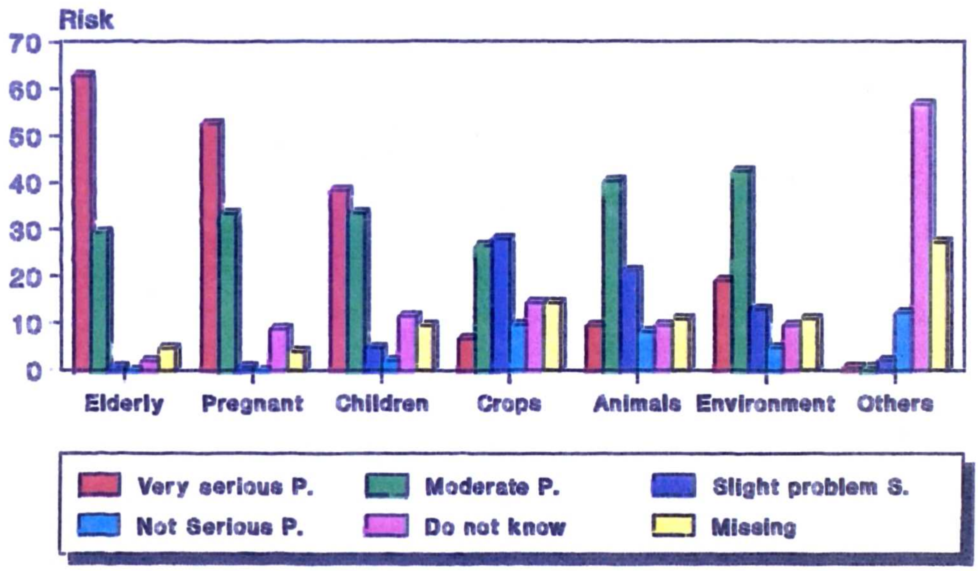


Figure 8.6.5

Hospital Incinerator Problems
Kolestan Hospital



Figyre 8.6.6

1. Other considerations.

The response indicates that 20.5% people would participate in any action against the installation of a hospital incinerator. Results from question 9 shows 15.8% believe it would bring no advantages while 58.9% agreed it would allow the disposal of hospital waste in a healthy way.

8.3.2 Survey findings from Emam Khomeini hospital

a. Age

The first question of the survey asked people about their ages. 168 people responded. The largest percentage of respondents (19.6%) were between 46 and 55 years old. The lowest percentage of respondents (4.2%) were 66 or more years old. See Figure 8.8.1.

b. Sex

To this question 168 people responded, 78% were men and 22% were women.

c. Education

From this question 8.3% were found to be illiterate. The response to this question showed that 53.6% had only Primary Education (7-11 years old), 9.5% completed

Guidance Education (12-14 years old), 22% finished High School (15-18 years old), 6.5% completed University.

d. Public concern over community problems.

Question one revealed concerns over community problems 73.2% of respondent were very often concerned about hospital incinerators, while 30.4% very often concerned about crime, 16.7% were very often concerned about accidents, 35.1% were very often concerned about smoking, 22% were concerned about risks at work and 19.6% were very often concerned about industrial pollution, and 32.1% were very often concerned about traffic. For details see Table 8.7.1 and Figure 8.7.2.

Table 8.7.1 Community problems

Level of perception / Problem	Very often %	Time to time %	Not much at all %	Don't know %	Missing %
Crime	30.4	25.0	42.3	0.6	1.8
Accident	16.7	44.6	32.7	0.6	5.4
Smoking	35.1	5.4	42.9	0.6	16.1
Risk at work	22.0	15.5	38.7	1.8	22.0
Industrial pollution	19.6	35.1	25.6	-	19.6
Hospital incinerator	73.2	19.0	4.2	-	3.6
Traffic	32.1	58.9	3.6	1.8	4.2

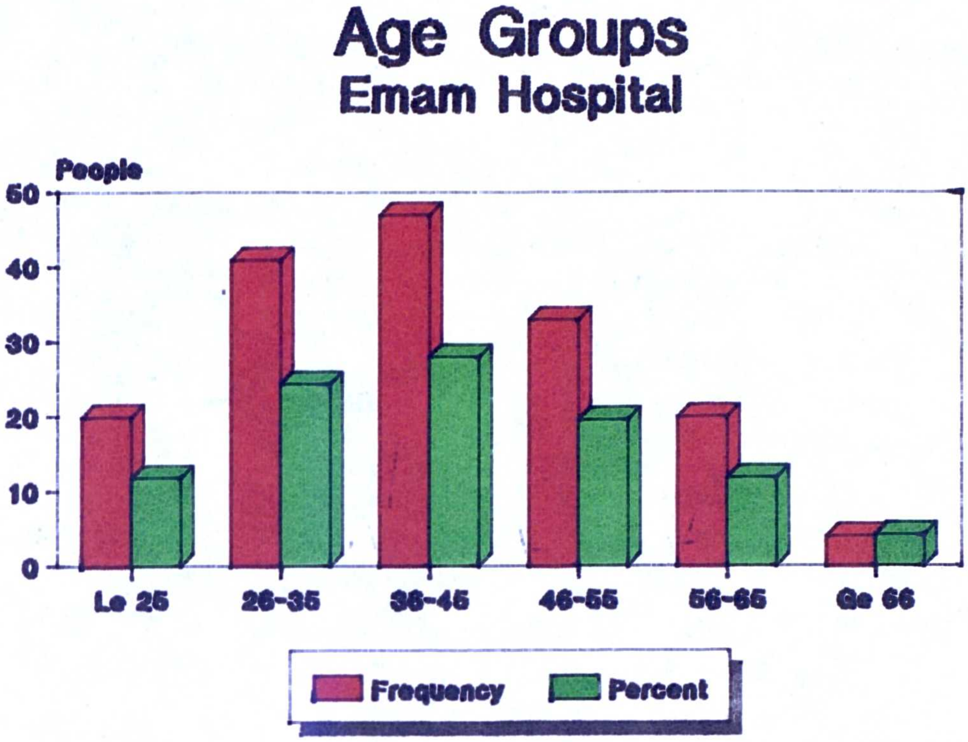


Figure 8.7.1

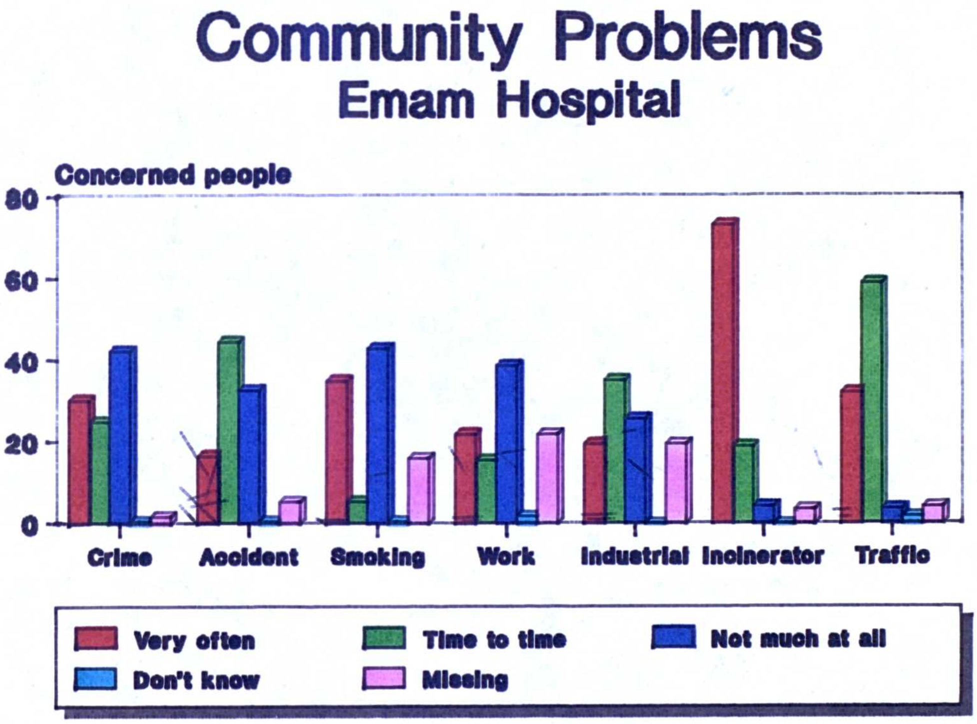


Figure 8.7.2

e. project awareness and risk perception.

The second question, of the questionnaire asked, "Are you aware of this project?". According to the respondents 22.6% knew that there was a project for the Emam Khomeini hospital (Ahwaz). The response indicated that 1.2% got the information about it through newspapers, 20.8% through friends, no person through leaflets, nobody through TV and 1.8% heard about it from other ways.

From the third question about possible problems caused by an incinerator 61.3% of respondents believed air pollution was a more serious risk than other problems. Table 8.7.2 and Figure 8.7.3 show the results from the respondents to question 3.

Table 8.7.2 Risk from hospital incinerator.

Level of risk / Problems	Very serious risk %	Moderate risk %	Not serious risk %	Do not know %	Missing %
Fire	60.1	32.7	2.4	2.4	2.4
Explosion	26.8	36.3	8.9	18.5	9.5
Water Pollution	13.7	26.8	8.9	29.2	21.4
Soil contamination	10.7	22.6	8.9	30.4	27.4
Smell	60.1	35.7	-	1.2	3.0
Noise risk	23.8	48.2	11.3	6.5	10.1
Air Pollution	61.3	26.8	0.6	3.0	8.3
Hazardous from big lorries	38.1	43.5	1.2	5.4	11.9
Other risk	1.8	14.3	1.8	42.9	39.3

f. Public concern over health problems.

34.5% of respondents to the fourth question, felt very seriously that they had had some trouble with their general health. According to responses 17.3% were very seriously concerned about eye irritation. Respiratory problems were a very serious concern to 17.3%. Tension concerned 33.3%, and skin irritation, rashes or spots were experienced by 22% very seriously. For more information see Table 8.7.3 and Figure 8.7.4.

Table 8.7.3 Health problems.

Level of risk / Problem	Very serious %	Moderate concern %	Not serious %	Do not know %	Missing %
General health	34.5	22.0	33.3	0.6	9.5
Eye irritation	17.3	11.9	44.0	0.6	26.2
Tension	33.3	25.0	22.0	0.6	19.0
Respiratory symptoms	17.3	13.1	33.9	4.8	31.0
Skin irritation	22.0	10.1	30.4	2.4	35.1

g. Possible problems from incinerator proximity.

According to question five the hospital incinerator is a cause of concern to 86.9% of those living near it. 81.5% were very greatly concerned while 1.8% were not worried at all. These findings were supported strongly by answers to questions 7, 10 and 11. A sizeable population (Question 7, 98.8%) is opposed to the idea that a hospital

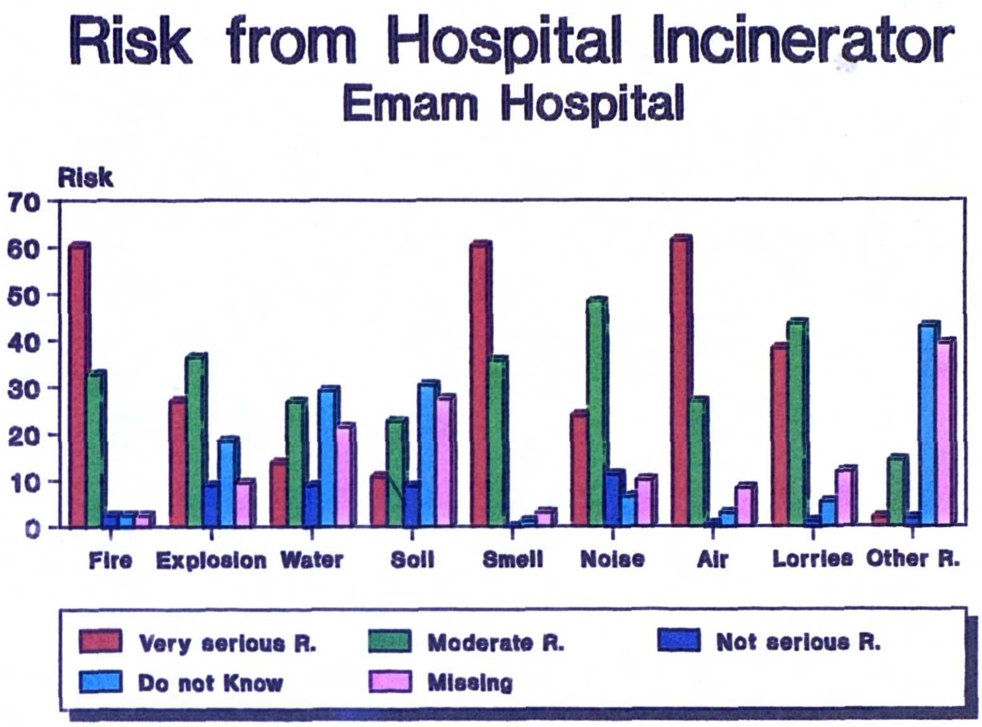


Figure 8.7.3

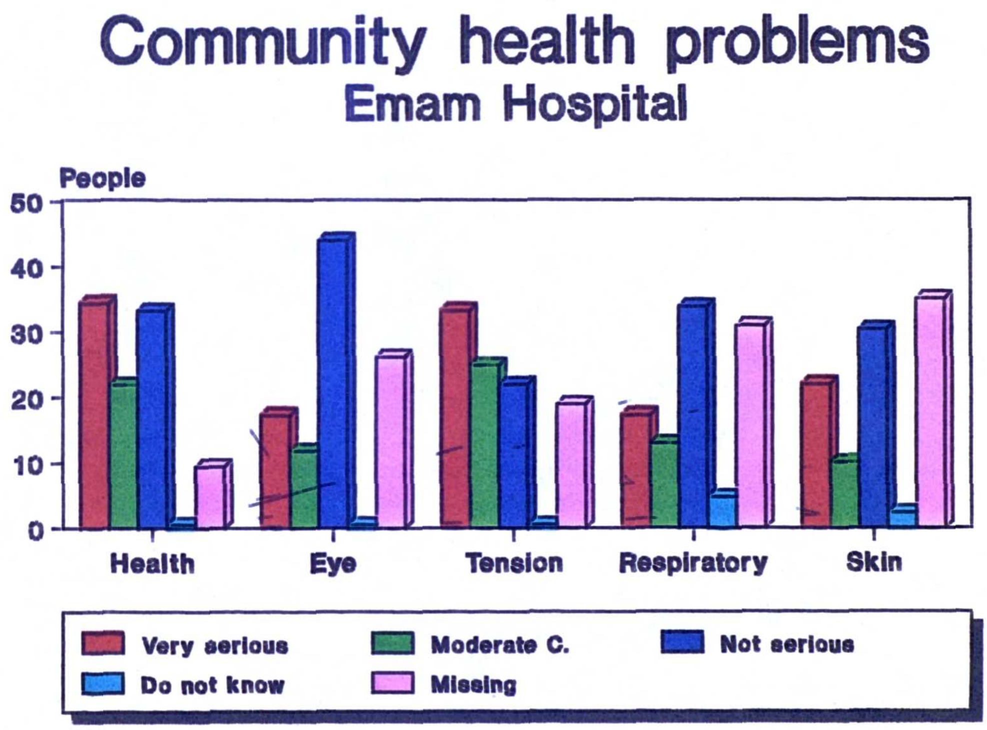


Figure 8.7.4

incinerator should be installed close to their homes.

If a hospital incinerator was to be installed close to their area (Question 10), 6.5% would move away but 89.3% would not move away. Also the most suitable site to install a hospital incinerator should be very far from their house (Question 11) according to 80.4% and far according to 7.1%.

h. Possible problems from factories.

Question six referred the effect of factories on the community. Fifty three point six percent of respondents were concerned about the effects of these emissions from factories on the health of aged people. Knowledge about the effect of such emissions on pregnant women was lacking in 71.4% respondents. Knowledge about the effects of emissions from factory chimneys on child health was well known to 49.4%, and 8.9% of respondent knew about the effect of these emissions on crops. Eleven point three percent thought the emissions caused a serious problem to the health of animals. Thirty two point seven percent have a firm belief that industries cause damage to the environment. Forty point five percent were ignorant about the other effects of these emissions from factories. See Table 8.7.4 and Figure 8.7.5.

Table 8.7.4 Possible problems from factories.

Level of risk / Case	Very serious problem	Mode -rate problem	Slight problem serious	Not serious problem	Do not know	Miss- ing
Elderly people	53.6	36.3	3.0	1.8	1.8	3.6
Pregnant women	71.4	22.0	1.2	0.6	3.0	1.8
Children	49.4	33.9	4.2	3.6	6.0	3.0
Crops	8.9	26.8	22.0	21.4	8.9	11.9
Animals	11.3	44.0	13.7	16.7	6.0	8.3
Environ -mental pollution	32.7	44.6	8.9	6.0	1.8	6.0
Others	2.4	5.4	10.7	14.9	40.5	26.2

i. Possible problems from a hospital incinerator

Though the effect of emissions from hospital incinerator chimneys upon elderly people (question 12) are known to be a very serious problem to 59.2%, 1.8% are completely ignorant about this aspect. Living in the vicinity of a hospital incinerator is a very serious problem for pregnant women according to 67.9%. A sizeable number (47.6%) of respondents know about the effects of emissions from a hospital incinerator's chimney on children. The response indicates that 5.4% of people believe very serious problems will be caused to crops. The effects on animals were well know to 10.7% of respondents.

Twenty two percent believe that hospital incinerators caused a very serious problem to the environment. Forty one point seven percent are ignorant about the other effects of these emissions. Table 8.7.5 and Figure 8.7.6 show the results from these respondents.

Table 8.7.5 Hospital incinerator problems.

Level of risk / Case	Very serious problem	Mode -rate problem	Slight problem serious	Not serious problem	Do not know	Miss- ing
Elderly people	54.2	38.7	2.4	0.6	1.8	2.4
Pregnant women	67.9	28.0	0.6	0.6	2.4	0.6
Children	47.6	31.0	7.1	3.0	7.7	3.6
Crops	5.4	22.0	20.8	25.6	10.7	15.5
Animals	10.7	50.0	11.9	16.1	3.6	7.7
Environ -mental pollution	22.0	51.8	7.1	8.3	4.8	6.0
Others	0.6	2.4	1.8	23.2	41.7	30.4

j. Other Considerations.

The response indicates that 7.1% of people would participate in any action against the installation of a hospital incinerator. 4.2% believe that it would bring no advantages while 77.4% agreed it would allow the disposal of hospital waste in a healthy way.

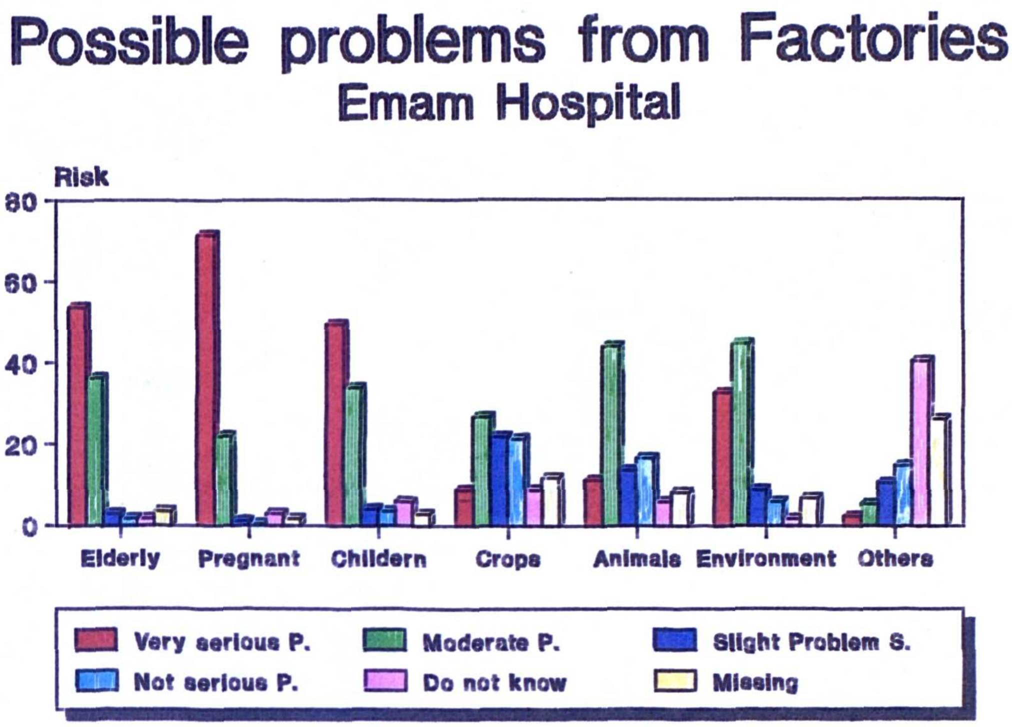


Figure 8.7.5

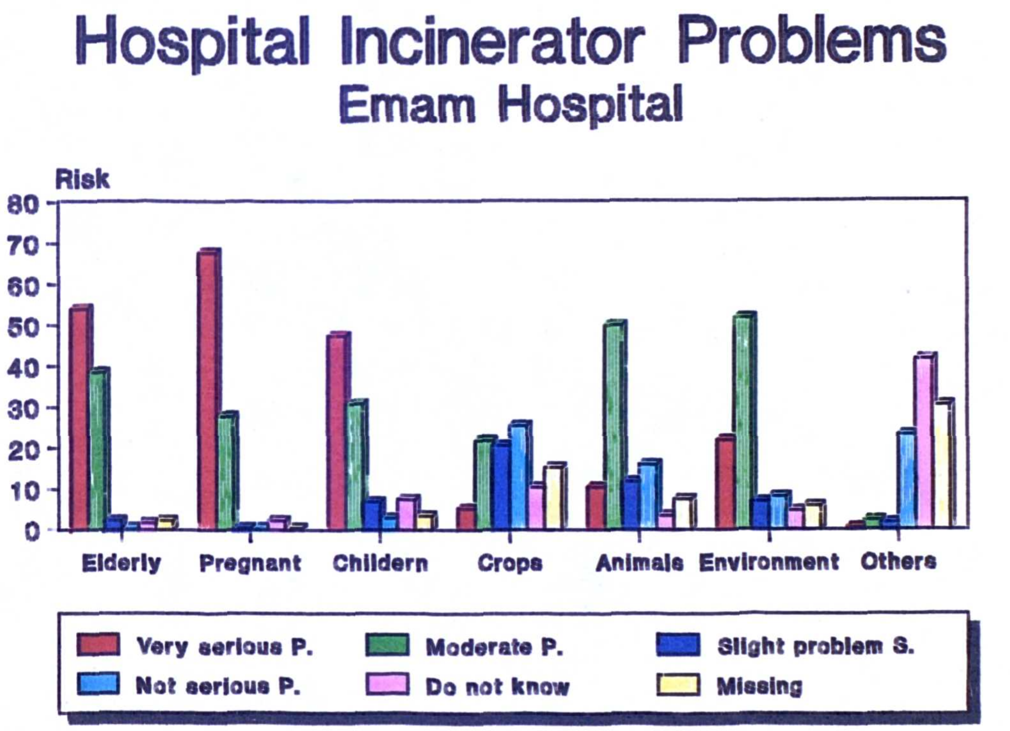


Figure 8.7.6

8.3.3 Survey findings from Razi hospital.

a. Age

The first question of the survey asked people about their ages, 131 people responded. The largest percentage of respondents (31.3%) were between 36 and 45 years old. The lowest percentage of respondents (0.8%) were 66 or more years old see Figure 8.8.1.

b. Sex

To this question 130 people responded, 59.5% of respondents were men and 39.7% were women.

c. Education

From this question 4.6% were found to be illiterate. The response to this question showed that 49.6% had only Primary Education (7-11 years old), 19.1% completed Guidance Education (12-14 years old). Nineteen point one percent finished High School (15-18 years old), 7.6% completed University.

d. Public concern over community problems.

Attitudes to seven community problems were surveyed in question one. 61.8% of respondents were very often concerned about hospital incinerators, while 13.0% were very often concerned about crime, 9.2% were very often concerned about accidents, 21.4% were very often concerned about smoking, 26.0% were concerned about risks at work, 11.5 % were very often concerned about industrial pollution, and 19.8% were very often concerned about traffic. For details see Table 8.8.1 and Figure 8.8.2.

Table 8.8.1 Community problems

Level of perception / Problem	Very often %	Time to time %	Not much at all %	Don't know %	Missing %
Crime	13.0	43.5	41.2	-	2.3
Accident	9.2	32.1	51.9	0.8	6.1
Smoking	21.4	13.0	52.7	2.3	10.7
Risk at work	26.0	16.8	38.9	5.3	13.0
Industrial pollution	11.5	38.2	33.6	6.1	10.7
Hospital incinerator	61.8	30.5	1.5	3.8	2.3
Traffic	19.8	67.9	7.6	1.5	3.1

e. Project awareness and risk perception.

The second question surveyed awareness of the project. According to the respondents 25.2% knew that there was an incinerator project for the Razi hospital (Ahwaz). The response indicated that 0.8% got the information about it through newspapers, 19.1% through friends, nobody through leaflets, and nobody through TV 5.3% heard about it from

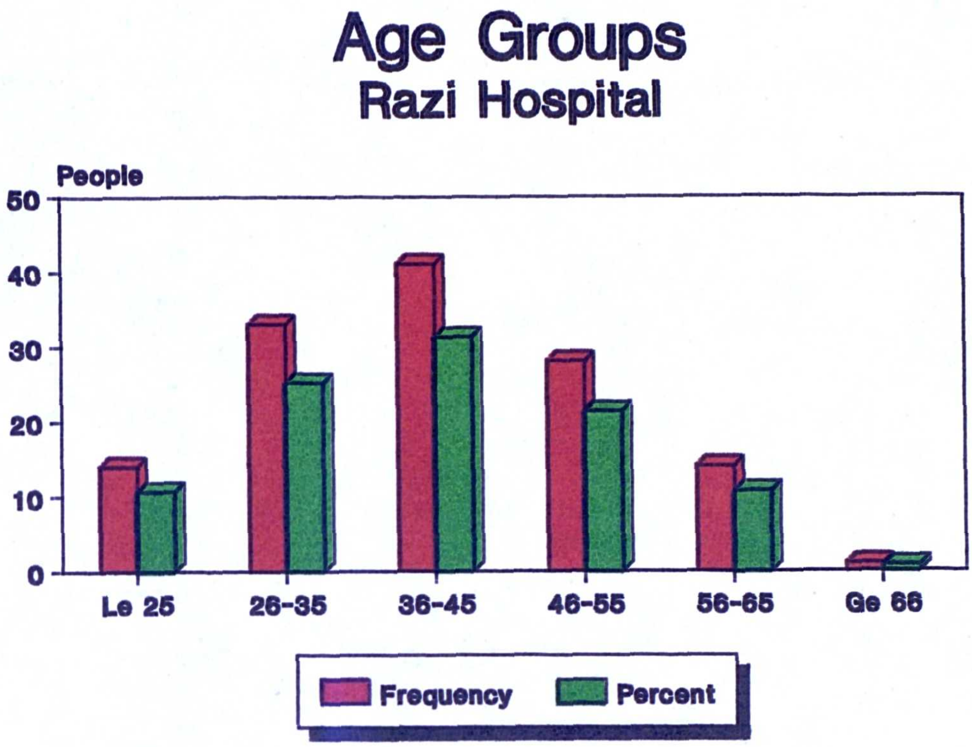


Figure 8.8.1

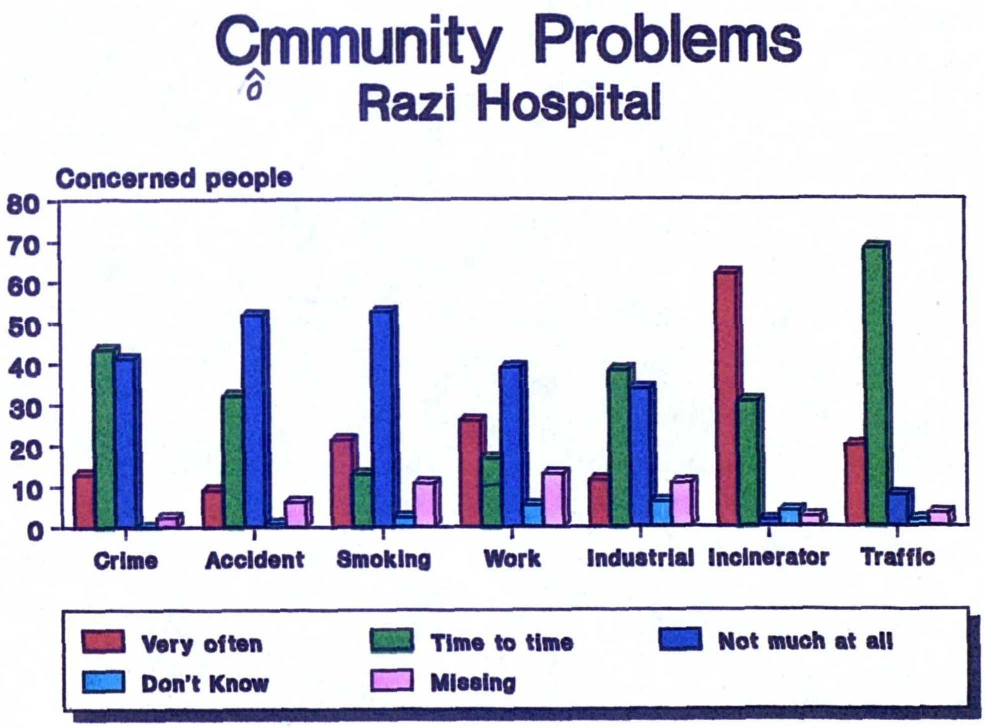


Figure 8.8.2

other ways.

Question three concerned possible problems caused by an incinerator. For this question 77.9% of respondent believed that smell was a more serious risk than other problems. Table 8.8.2 and Figure 8.8.3 show the results from the respondents to question 3.

Table 8.8.2 Risk from hospital incinerator.

Level of risk / Problems	Very serious risk	Moderate risk	Not serious risk	Do not know	Missing
Fire	68.7	28.2	-	2.3	0.8
Explosion	24.4	42.0	14.5	13.0	6.1
Water Pollution	28.2	33.6	11.5	17.6	9.2
Soil contamination	17.6	35.1	18.3	13.7	15.3
Smell	77.9	17.6	1.5	-	3.1
Noise risk	13.7	35.1	30.5	10.7	9.9
Air Pollution	62.6	29.0	1.5	1.5	5.3
Hazardous from big lorries	45.0	45.8	3.1	2.3	3.8
Other risk	2.3	9.2	16.0	45.8	26.7

f. Public concern over health problems.

Forty four point three percent of respondents to the fourth question, felt very seriously that they had had some trouble with their general health. According to the responses 13.7% were very seriously concerned about eye irritation. Respiratory problems were a very serious to

15.3%. Tension concerned 29.0% and skin irritation, rashes or spots were experienced by 32.8% very seriously. For more information see Table 8.8.3 and Figure 8.8.4.

Table 8.8.3 Health Problems.

Level of risk / Problem	Very serious	Moderate concern	Not serious	Do not know	Missing
General health	44.3	29.0	22.1	-	4.6
Eye irritation	13.2	23.7	33.6	1.5	27.5
Tension	29.0	33.6	-	0.8	16.0
Respiratory symptoms	15.3	17.6	37.4	2.3	27.5
Skin irritation	32.8	19.1	22.1	2.3	23.7

g. Possible problems from incinerator proximity

According to question five, the hospital incinerator is a cause of concern to 64.1% of those living near it. Of these 58.8% very greatly were concerned while 0.8% was not worried at all. These findings where supported by answers to questions 7, 10 and 11. A sizeable population (Question 7, 90.1%) is opposed to the idea that a hospital incinerator should be installed close to their homes.

If a hospital incinerator is to be installed close to their area (Question 10), 9.9% would like to move away but

Risk from Hospital Incinerator
Razi Hospital

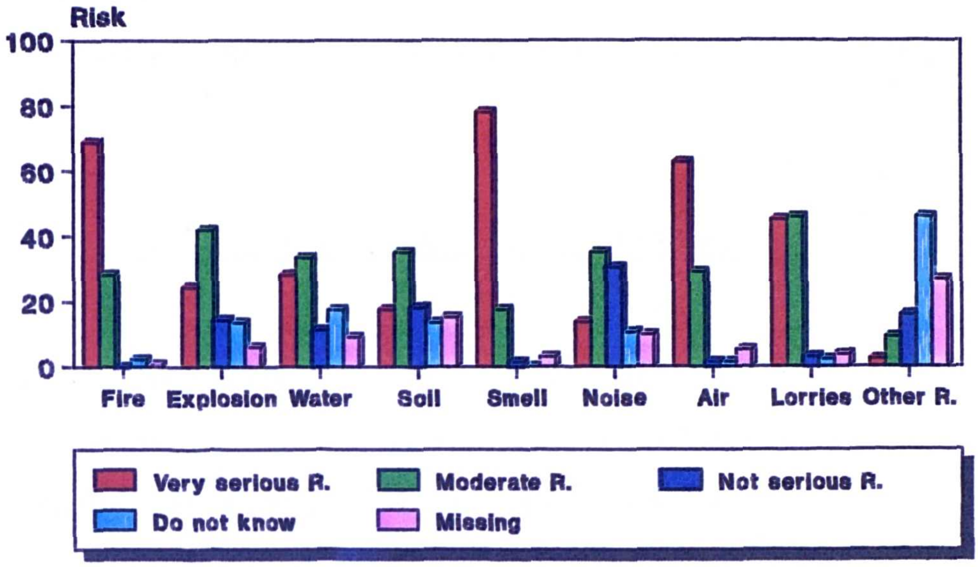


Figure: 8.8.3

Community health problems
Razi Hospital

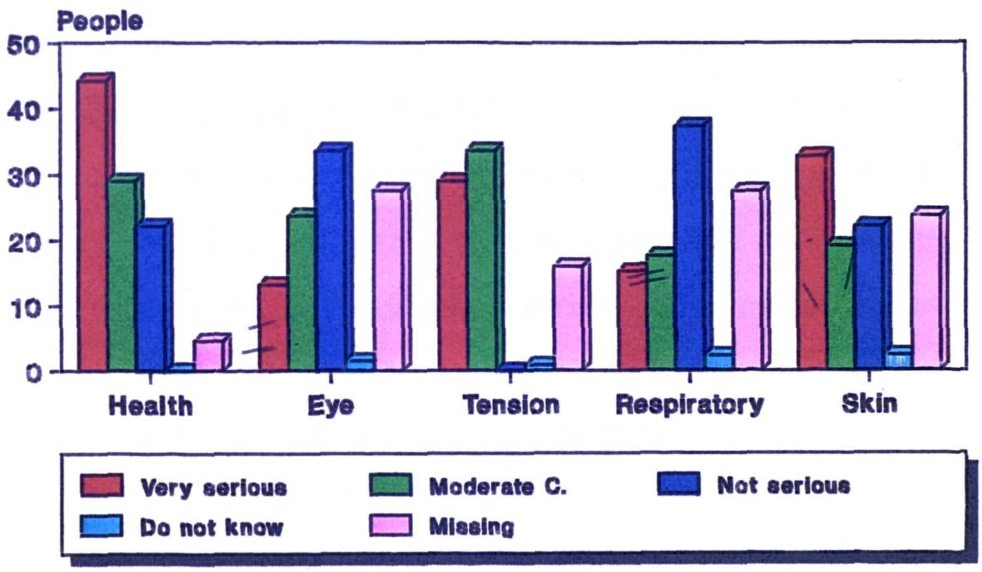


Figure 8.8.4

70.2% would not move away. Also the most suitable distance to install a hospital incinerator (Question 11) should be very far from their house according to 74.0% and far according to 6.9%. Nobody wants to live close by.

h. Possible problems from factories.

Question 6 referred the effect of factories on the community. Sixty four point nine percent were concerned about the effects of these emissions from factories on the health of aged people. Seventy point two percent had no knowledge about the effect of such emissions on pregnant women. Knowledge about the effects of emissions from factories chimney on child health was well know to 47.3% of responses. Eighteen point three percent of respondent knew about the effect of these emission on crops. Twenty point six percent thought the emissions caused a serious problem to the health of animals. Fifty point four percent have a firm belief that industries cause damage to the environment. Thirty five point nine percent were ignorant about the other effects of these emissions from factories. See Table 8.8.4 and Figure 8.8.5.

Table 8.8.4 Possible problems from factories.

Level of risk / Case	Very serious problem	Mode -rate problem	Slight problem serious	Not serious problem	Do not know	Miss-ing
Elderly people	64.9	23.7	1.5	0.8	0.8	8.4
Pregnant women	70.2	16.0	4.6	-	1.5	7.6
Children	47.3	24.4	9.9	3.8	3.1	11.5
Crops	18.3	24.4	16.0	16.0	6.1	19.1
Animals	20.6	36.6	13.0	9.2	3.1	17.6
Environ -mental pollution	50.4	24.4	3.8	3.8	1.5	16.0
Others	0.8	3.1	3.8	22.1	35.9	34.4

i. Possible problems from a hospital incinerator.

Through the effect of emissions from hospital incinerator chimneys upon elderly people (Question 12) are known to be a very serious problem to 70.2%, 0.8 % are completely ignorant about this aspect. Living in the vicinity of a hospital incinerator is a very serious problem for pregnant women according to 72.5%. A sizeable number, 54.2% respondents, know about the effects of emissions from a hospital incinerator's chimney on children. The response indicates that 9.9% of people believe a very serious problem will be caused to crops. The effects on animals were well know to 26.0% and 44.3% believe that hospital incinerators are a very serious problem to the environment. Thirty five point one percent are ignorant about the other effects of these emission. Table 8.8.5 and Figure 8.8.6 show results from these responses.

Table 8.8.5 Hospital incinerator problems.

Level of risk / Case	Very serious problem	Mode -rate problem	Slight problem serious	Not serious problem	Do not know	Miss- ing
Elderly people	70.2	18.3	-	-	0.8	10.7
Pregnant women	72.5	15.3	7.6	-	-	4.6
Children	54.2	22.1	3.8	3.1	4.6	12.2
Crops	9.9	30.5	16.8	13.0	1.5	28.2
Animals	26.0	31.3	9.2	7.6	1.5	24.4
Environ -mental pollution	44.3	28.2	3.1	3.8	3.1	17.6
Others	0.8	2.3	2.3	23.7	35.1	35.9

j. Other considerations.

The response indicates that 6.9% of people would participate in any action against the installation of a hospital incinerator. 14.5% believe that it would bring no advantages while 78.6% agreed it would allow the disposal of hospital waste in a healthy way.

Possible problems from Factories
Razi Hospital

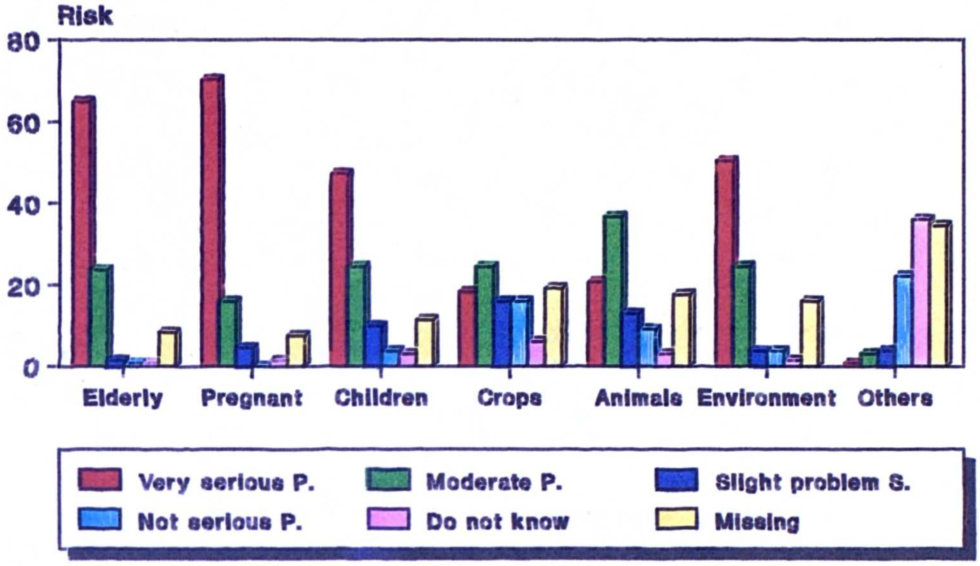


Figure 8.8.5

Hospital Incinerator Problems
Razi Hospital

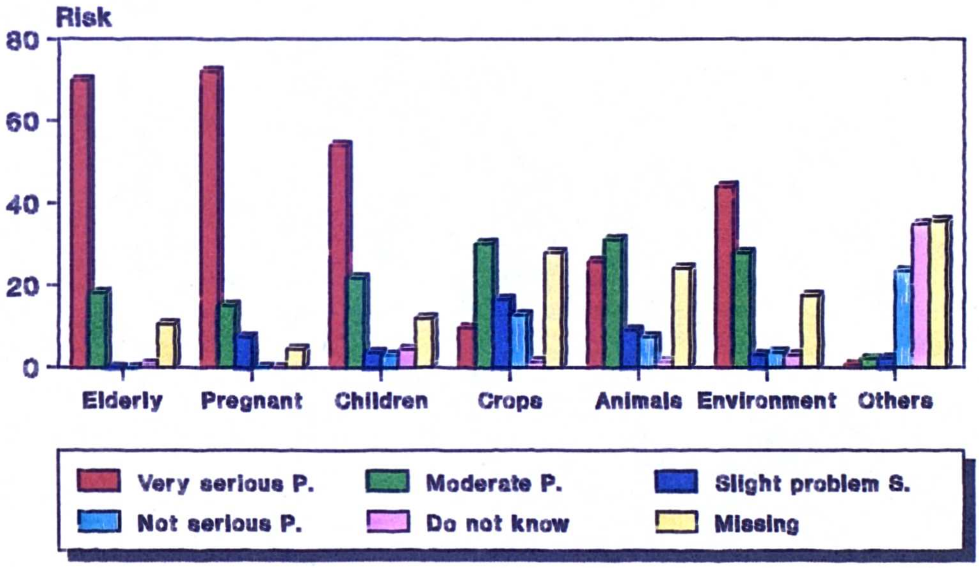


Figure 8.8.6

8.3.4 Survey findings from Sina hospital.

a. Age

The first question of the survey asked people about their ages. No person was missing, therefore 109 people responded. The largest percentage of respondents (49.6%) were between 36 and 55 years old. The lowest percentage of respondents (6.4%) were 66 or more years old. See Figure 8.9.1.

b. Sex

To this question, 109 people responded. Seventy eight percent of respondents were men and 22.0% were women.

c. Education

This question showed 19.3% of respondents were illiterate. The response to this question showed that 57.8% had only Primary Education (7-11 years old), 13.8% completed only Guidance Education (12-14 years old), 7.3% finished High School (15-18 years old) and 1.8% graduated from University.

d. Public concern over community problems.

Peoples concerns over seven community problems were revealed. in question one. Twenty five point seven percent of respondent were very often concerned about hospital incinerators, 22.0% were very often concerned about crime, 10.1% were very often concerned about accidents, 37.6% were very often concerned about smoking, 33.0% were concerned about risks at work, 3.7% were very often concerned about industrial pollution, and 15.6% were very often concerned about traffic. For details see Table 8.9.1 and Figure 8:9.2.

Table 8.9.1 Community problems.

Level of perception / Problem	Very often %	Time to time %	Not much at all %	Don't know %	Missing %
Crime	22.0	32.1	45.9	-	-
Accident	10.1	41.3	47.7	-	0.9
Smoking	37.6	16.5	40.4	1.8	3.7
Risk at work	33.0	12.8	43.1	6.4	4.6
Industrial pollution	3.7	14.7	70.6	6.4	4.6
Hospital incinerator	25.7	56.0	13.8	3.7	0.9
Traffic	15.6	61.5	18.3	1.8	2.8

e. Project awareness and risk perception.

The second question, on project awareness, showed that 17.9% of respondents knew that there was a project for the

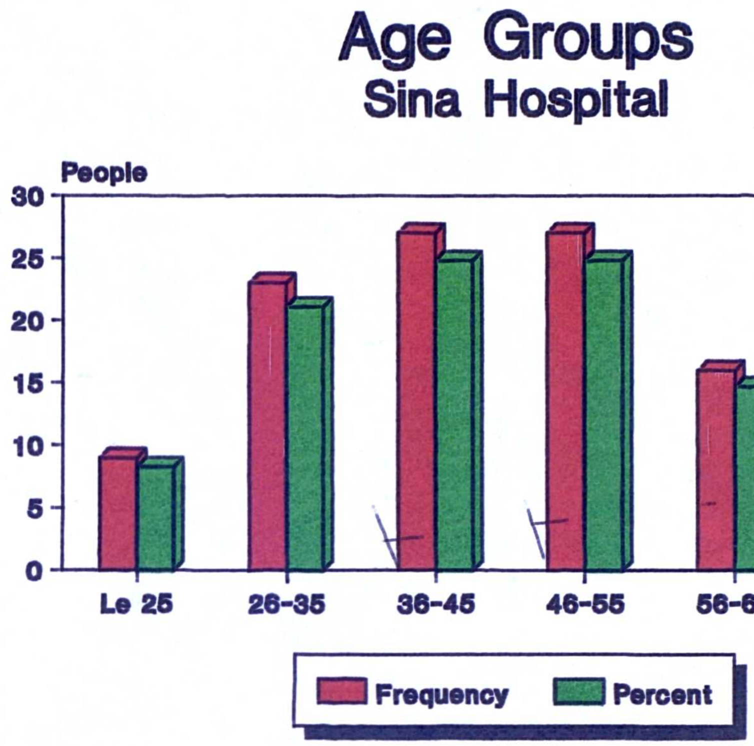


Figure 8.9.1

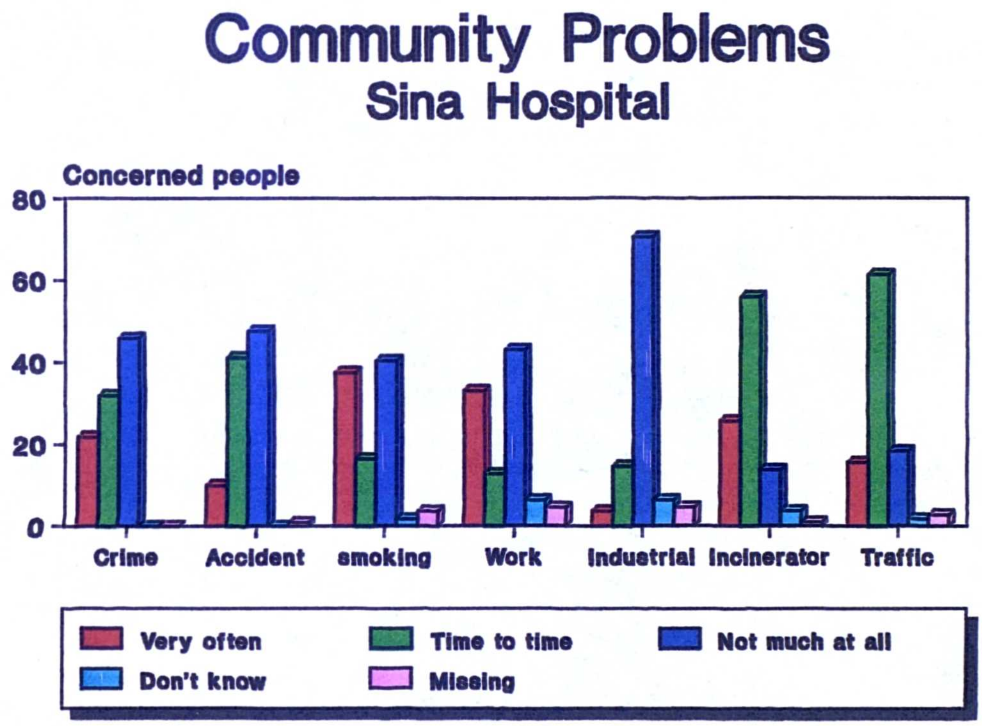


Figure 8.9.2

Sina hospital (Ahwaz) but 74.3% did not know that there was a project for that area. The response indicated that 0.9% got the information about it through newspapers, 13.8% through friends, 0.9% through leaflets, nobody through TV and 1.8% heard about it from other ways.

Question three revealed that 78.9% of respondent believed that smell was a more serious risk than other problems. Table 8.9.2 and Figure 8.9.3 show the results from the respondents to question three.

Table 8.9.2 Risk from hospital incinerator.

Level of risk / Problems	Very serious risk	Moderate risk	Not serious risk	Do not know	Miss-ing
Fire	66.1	26.6	2.8	4.6	-
Explosion	18.3	40.4	12.8	25.7	2.8
Water Pollution	31.2	21.1	18.3	23.9	5.5
Soil contamination	31.2	24.8	18.3	18.3	7.3
Smell	78.9	17.4	1.8	1.8	-
Noise risk	11.0	24.8	54.1	4.6	5.5
Air Pollution	53.2	40.4	3.7	2.8	-
Hazardous from big lorries	34.9	52.3	3.7	2.8	6.4
Other risk	0.9	5.5	15.6	38.5	39.4

f. Public concern over health problems.

49.5% of respondents to the fourth question felt very seriously that they had had some trouble with their general health. According to responses 21.1% were very seriously concerned about eye irritation. Respiratory problems were a very serious concern to 14.4%. Tension concerned 26.6% and skin irritation, rashes or spots were experienced by 21.1% very seriously. For more information see Table 8.9.3 and Figure 8.9.4.

Table 8.9.3 · Health problems.

Level of risk / Problem	Very serious	Moderate concern	Not serious	Do not know	Missing
General health	49.5	31.2	16.5	0.9	1.8
Eye irritation	21.1	18.3	47.7	-	12.8
Tension	26.6	36.7	32.1	-	4.6
Respiratory symptoms	14.7	20.2	45.0	9.2	1.0
Skin irritation	21.1	16.5	42.2	9.2	11.0

g. Possible problems from incinerator proximity.

According to question five, the hospital incinerator is a cause of concern to 68.8% of those living near it, of these 63.3% were very greatly concerned. These findings were supported by questions 7, 10 and 11. A sizeable

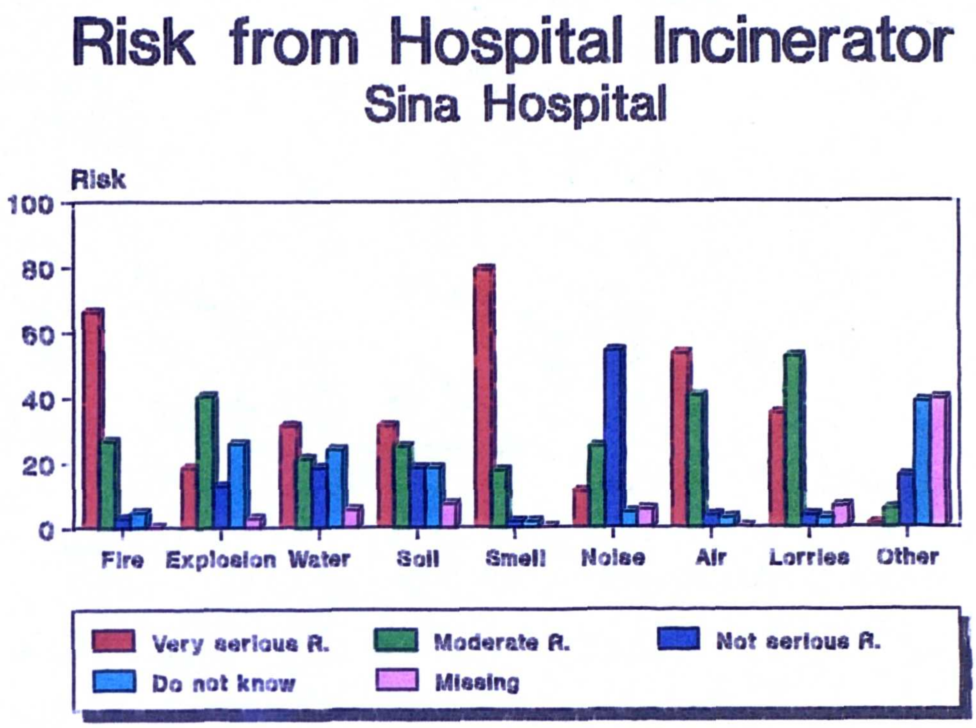


Figure 8.9.3

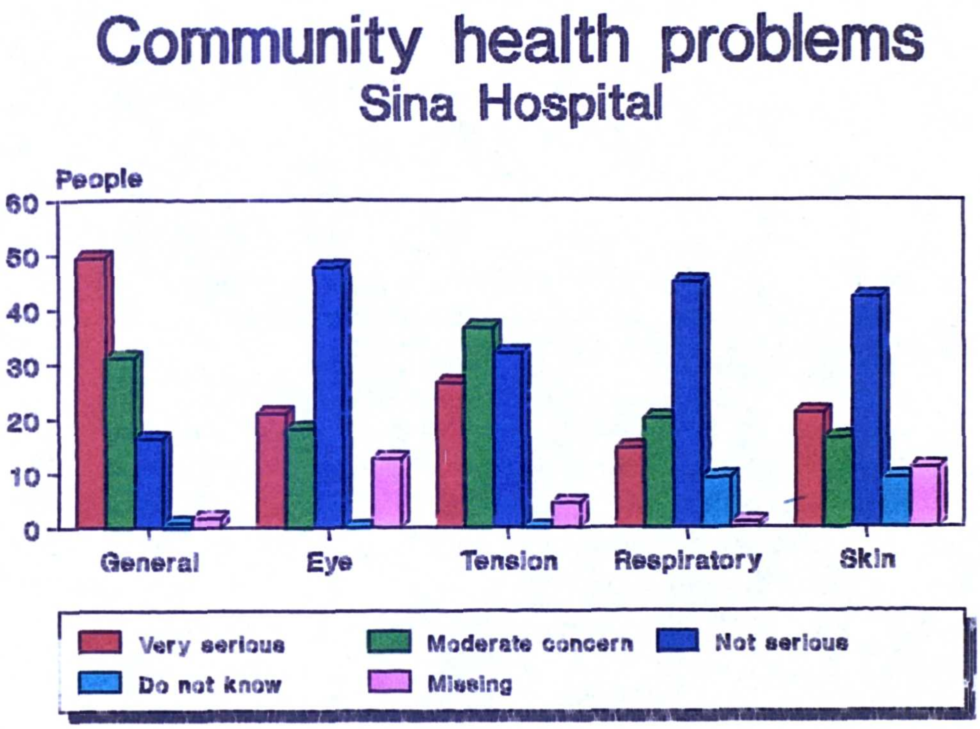


Figure 8.9.4

population (Question 7, 84.4%) is opposed to the idea that a hospital incinerator should be installed close to their homes.

For example if a hospital incinerator is to be installed close to their area (Question 10), 2.8% would like to move away but 80.7% would not move away. Also the most suitable distance to install a hospital incinerator would be very far from their house according to 78.0% and far from according to 2.8% (Question 11).

h. Possible problems from factories.

Question 6 referred to the effect of factories on the community. Sixty eight point eight percent were concerned about the effects of these emissions from factories on the health of aged people. Fifty three point two percent knew about the effect of such emissions on pregnant women. Knowledge about the effects of emissions from factory chimneys on child health was well know to 43.1% and 17.4% of respondent knew about the effect of these emissions on crops. Ten point one percent thought the emissions caused a very serious problem to the health of animals. Twenty six point six percent have a firm belief that industries cause damage to the environment. Fifty four point one percent were ignorant about the other effects of these emissions from factories. See Table 8.9.4 and Figure 8.9.5.

Table 8.9.4 Possible problems from factories.

Level of risk / Case	Very serious problem	Mode -rate problem	Slight problem serious	Not serious problem	Do not know	Miss-ing
Elderly people	68.8	18.3	1.8	0.9	4.6	5.5
Pregnant women	53.2	28.4	7.3	0.9	6.4	3.7
Children	43.1	31.2	5.5	7.3	7.3	5.5
Crops	17.4	19.3	20.2	16.5	11.0	15.6
Animals	10.1	26.6	19.3	21.1	10.1	12.8
Environ -mental pollution	26.6	32.1	11.0	7.3	-	9.2
Others	1.8	6.4	4.6	8.3	54.1	24.8

i. Possible problems from a hospital incinerator.

Through the effect of emissions from hospital incinerator chimneys upon elderly people (Question 12) are known to be a very serious problem to 62.4%, 8.3% were completely ignorant about this aspect. Living in the vicinity of a hospital incinerator is a very serious problem for pregnant women according to 56.9%. A sizeable number, 43.1% of respondents, knew about the effects of emissions from a hospital incinerator's chimney on children. The response indicates that 7.3% of people believe that a very serious problem will be caused to crops. The effects on animals were well know to 11.9% and 18.3% believed that hospital incinerators were a very serious problem to the environment. Eleven percent were ignorant about the other effects of these emissions. Table 8.5 and Figure 8.5.6 show these responses.

Table 8.9.5 Hospital incinerator problems.

Level of risk / Case	Very serious problem	Mode -rate problem	Slight problem serious	Not serious problem	Do not know	Miss- ing
Elderly people	62.4	22.9	3.7	-	2.8	8.3
Pregnant women	66.9	31.2	5.5	-	4.6	1.8
Children	43.1	33.9	5.5	5.5	6.4	5.5
Crops	7.3	17.4	27.5	19.3	6.4	22.0
Animals	11.9	30.3	14.7	16.5	5.5	21.1
Environ -mental pollution	18.3	36.7	7.3	7.3	11.0	19.3
Others	0.9	1.8	-	3.7	52.3	41.3

j. Other considerations

The response (Question 8) indicates that 1.8% of people would participate in any action against the installation of a hospital incinerator. Results from question seven shown that 27.5% believe that it would bring advantages while 73.4% agreed it would allow the disposal of hospital waste in a healthy way.

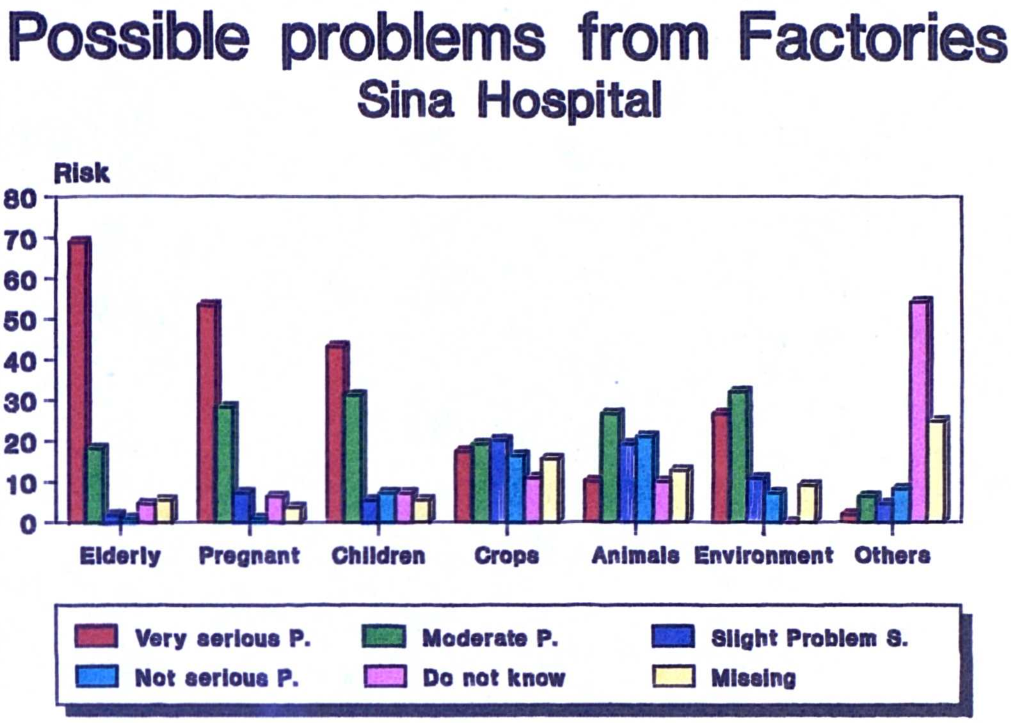


Figure 8.9.5

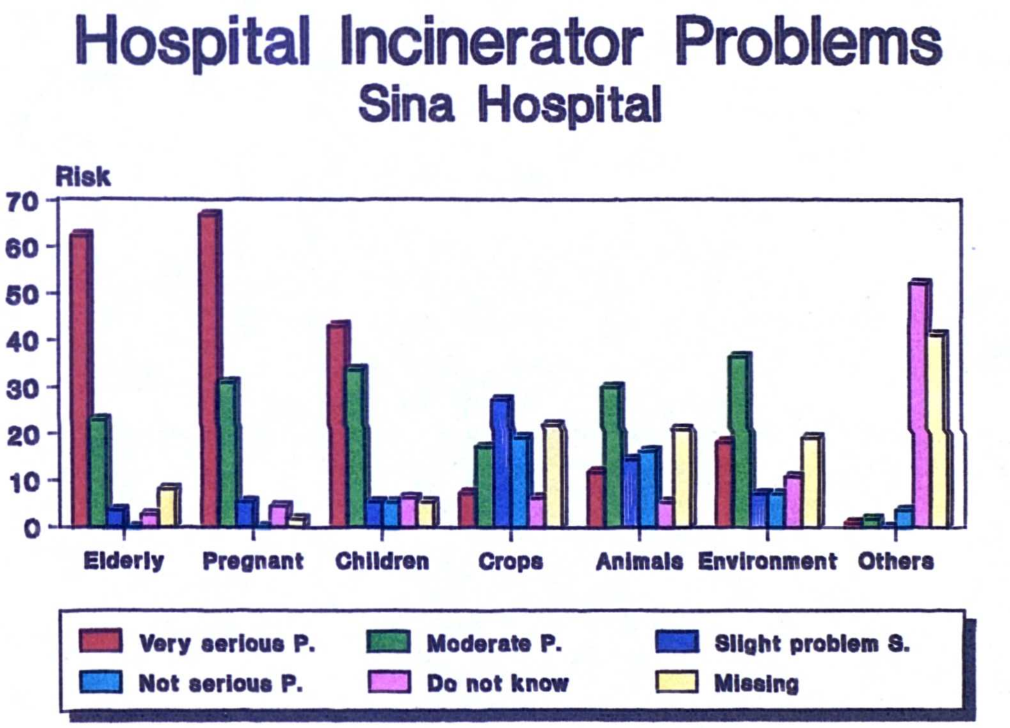


Figure 8.9.6

8.3.5. Discussion

Tables 8.10.1. and 8.10.2. show the data related to cross tabulation of participants' residential distance and their risk perception (Ahwaz).

Table 8.10.1 Ahwaz-Residential distance and risk perception.

V65 HOW FAR AWAY SHOULD THE INCINERATOR BE
by V63 ARE YOU CONCERNED ABOUT LIVING NEAR AN INCINERATOR

V63 Exp Val / V65	Yes	No	Missing	Row Total
Close	1.5 -1.5	.4 1.6	.1 -.1	2 .4%
Far	30.5 -3.5	8.8 5.2	1.7 -1.7	41 7.4%
Very far	313.1 8.9	90.4 -7.4	17.5 -1.5	421 76.0%
Do not know	61.7 -1.7	17.8 -1.8	3.4 3.6	83 15.0%
Missing	5.2 -2.2	1.5 2.5	.3 -.3	7 1.3%
Column total	412 74.4%	119 21.5%	23 4.2%	554 100.0%

As the data of Table 8.10.1, above, indicate the closer the people live to the hospital the more concerned they seem to be and vice versa. The results of the Chi-square analyses on the differences among their risk perceptions showed that the residuals of the obtained frequencies and the expected frequencies in each cell are statistically significant [K = 22.73, df = 8, P = 0.0037].

Table 8.10.2 Ahwaz-Desire to move and risk perception.

V64 HOW MUCH ARE YOU CONCERNED ABOUT HOSPITAL INCINERATORS
by V51 MOVE AWAY IF AN INCINERATOR IS TO BE CLOSE

V51 Exp Val Residual V64	Yes	No	Missing	Row Total
Very great	24.9 .1	300.8 3.2	37.3 -3.3	363 65.5%
Moderate	2.1	25.7 1.3	3.2 .8	31 5.6%
Slight	.8 .2	9.9 1.1	1.2 -1.2	12 2.2%
Not at all	.3 2.7	3.3 -2.3	.4 -.4	4 .7%
Missing	9.9 -.9	119.3 -3.3	14.8 4.2	144 26.0%
Column	38 6.9%	459 82.9%	57 10.3%	554 100.0%

Also the results (Table 8.10.2) of the Chi-square analyses on the obtained differences among their risk perceptions showed that the residuals of the obtained frequencies and the expected frequencies in each cell are statistically significant [K = 34.57, df = 8, P = 0.0000] These results, therefore, support the existing association between the dependent variable and independent variable.

To sum up, the above data clearly indicate that the . . . data in the above tables are quite supportive of the prediction made in hypothesis 1 which assumed a significant association between residential distance from the hospital and the risk perception towards a hospital incinerator. The finding of this study is consistent with both Chi-squares.

Turning now to the age variable, Tables 8.10.3 and 8.10.4 show the cross tabulation of the data related to the age of the participants and their risk perception.

Table 8.10.3 Ahwaz-age and risk perception.

V63 ARE YOU CONCERNED ABOUT LIVING NEAR A HOSPITAL INCINERATOR

Age Exp Val Residual V63	Le 25	26-35	36-45	46-55	56-65	Ge 66	Row total
Yes	52.1 -4.1	93.0 -9.0	107.1 2.9	91.5 4.5	52.1 2.9	16.4 2.6	412 74.4%
No	15.0 5.0	26.9 7.1	30.9 -3.9	26.4 -5.4	15.0 -1.0	4.7 -1.7	119 21.5%
Missing	2.9 -.9	5.2 1.8	6.0 1.0	5.1 .9	2.9 -1.9	.9 -.9	23 4.2%
Total	70 12.6 %	125 22.6 %	144 26.0%	123 22.2 %	70 12.6 %	22 4.0%	554 100.0 %

Table 8.10.4 Ahwaz-Age and detail risk perception.
HOW MUCH ARE YOU CONCERNED ABOUT HOSPITAL INCINERATOR(by AGE group).

Age Exp Val Residual V 64	Le 25	26-35	36-45	46-55	56-65	ge 66	Row Total
Very great	45.9 -2.9	81.9 -7.9	94.4 2.6	80.6 3.4	45.9 3.1	14.4 1.6	363 65.5%
Moderate	3.9 -1.9	7.0 1.0	8.1 -.1	6.9 1.1	3.9 -.9	1.2 .8	31 5.6%
Slight	1.5 2.5	2.7 -1.7	3.1 -1.1	2.7 .3	1.5 .5	.5 -.5	12 2.2%
Not at all	.5 -.5	.9 1.1	1.0 1.0	.9 -.9	.5 -.5	.2 -.2	4 .7%
Total	70 12.6 %	125 22.6 %	144 26.0%	123 22.2%	70 12.6%	22 4.0%	554 100.0 %

As Tables 8.10.3 and 8.10.4 show, the older the people the more concerned they are. The results of the Chi-square analyses indicated that the obtained residuals in each cell between the obtained and expected frequencies are quite significant [K = 11.33, df = 10, P =.3316] These results are therefore consistent with the assumption made in hypothesis 2 which predicted "There is a significant relationship between risk perception and age" and so support hypothesis two. The results from Table 8.4 [K= 17.60, df = 20, P =.6132] showed that detailed questions did not support this hypothesis.

For the sex variable, Tables 8.5 and 8.6 show the cross tabulation of the data related to sex of the participants and their risk perception

Table 8.10.5 Ahwaz-Sex and risk perception.
ARE YOU CONCERNED ABOUT LIVING NEAR A HOSPITAL INCINERATOR (by SEX)

Sex Exp Val Residual V 63	Male	Female	Missing	Row Total
Yes	302.7 1.3	107.8 -1.8	1.5 .5	412 74.4%
No	87.4 1.6	31.1 -1.1	.4 -.4	119 21.5%
Missing	16.9 -2.9	6.0 3.0	.1 -.1	23 4.2%
Total	407 73.5%	145 26.2%	2 .4%	554 100.0%

Table 8.10.6 Ahwaz-Sex and detailed risk perception.

V64 HOW MUCH ARE YOU CONCERNED ABOUT HOSPITAL INCINERATOR

Sex Exp val Residual V 64	Male	Female	Missing	Row Total
Very great	266.7 5.3	95.0 -4.0	1.3 -1.3	363 65.5%
Moderate	22.8 .2	8.1 -1.1	.1 .9	31 5.6%
Slight	8.8 -1.8	3.1 .9	.0 1.0	12 2.2%
Not at all	2.9 .1	1.0 .0	.0 .0	4 .7%
Missing	105.8 -3.8	37.7 4.3	.5 -.5	144 26.0%
Total	407 73.5%	145 26.2%	2 .4%	554 100.0%

As Tables 8.10.5 and 8.10.6 show, when the respondents were asked a yes/no question, the results showed that there was no significant relationship between risk perception and sex [K= 2.76, df = 4, P = 0.5972] but when the question was asked in a more detailed manner, we can see that the results [K= 31.69, df= 8, P= 0.0001] are supportive of the assumption made in hypothesis 3.

Turning now to the education variable, Tables 8.7 and 8.8 show the cross tabulation of the data related to the education of the participants and their risk perception of a hospital waste incinerator.

Table 8.10.7 Ahwaz-Education and risk perception.

ARE YOU CONCERNED ABOUT LIVING NEAR A HOSPITAL INCINERATOR (BY EDUCATION)

Education Exp Val Residual V 63	lite - racy	Pri- mary	Secon -dary	Higher educat -ion	Unive - rsity	Miss -ing
Yes	38.7 -.7	220.1 15.9	57.3 -6.3	72.1 -10.1	23.1 1.9	.7 -.7
No	11.2 -.2	63.6 -17.6	16.5 7.5	20.8 10.2	6.7 -.7	.2 .8
Missing	2.2 .8	12.3 1.7	3.2 -1.2	4.0 .0	1.3 -1.3	.0 .0
Total	52 9.4%	296 53.4%	77 13.9%	97 17.5%	31 5.6%	1 .2%

Table 8.10.8 Ahwaz-Education and detailed risk perception.
HOW MUCH ARE YOU CONCERNED ABOUT HOSPITAL INCINERATOR (BY EDUCATION)

Education Exp val Residual V 64	lite- reacy	Pri- mary	Secoun- dary	Higher Educa -tion	Univer -sity	Miss -ing
Very great	34.1 -1.1	193.9 13.1	50.5 -5.5	63.6 -9.6	20.3 3.7	.7 -.7
Moderate	2.9 1.1	16.6 3.4	4.3 -.3	5.4 -.4	1.7 -1.7	.1 -.1
Slight	1.1 -1.1	6.4 -2.4	1.7 .3	2.1 2.9	.7 .3	.0 .0
Not at all	.4 -.4	2.1 -.1	.6 .4	.7 .3	.2 -.2	.0 .0
Total	52 9.4%	296 53.4%	77 13.9%	97 17.5%	31 5.6%	1 .2%

As the data of the above table 8.7 indicates the people who were educated more than others were more concerned, and vice versa. [K= 22.63, DF= 10, P= .0121] The results of the Chi-square analyses on the obtained differences among their risk perceptions showed that the residuals of the obtained frequencies and the expected frequency in each cell are statistically significant.

These result are therefore consistent with the assumption of a relationship between risk perception and education when asked a yes or no question but when asked in detail it is not statistically significant [K=25.288, DF= 20 P=.1906].

CHAPTER NINE

HEALTH ASPECTS OF HOSPITAL WASTE INCINERATORS

9.1 Introduction

The incineration of hospital waste is used mainly as a means of achieving the maximum volume reduction of the waste and the destruction of pathogens. Although not necessarily so, it is usually a more costly method of disposal than is controlled tipping and, for this reason, it has not generally been adopted when an authority has access to long term tipping facilities. A problem of increasing importance is that of collection and disposal of solid waste, including refuse from hospitals.

It is possible that the failure to deal satisfactorily with the never-ending flow of hospital solid waste may constitute a threat to public health and may also contribute to soil, water and air pollution as well as encouraging flies, rodents and other vectors of disease. The above is a very important statement; pollution of air, water and land is causing increasing and very serious concern in many cities. The growth of public concern relating to municipal incinerators in general and particularly to hospital incinerators leads to the widespread fear of hidden health risks through exposure to substances produced by an incinerator that could possibly lead to irreversible disease processes.

While heart disease is the leading cause of mortality in the developed countries, cancer is the most dreaded.

There appears to be a public perception that if dioxins are carcinogenic, mutagenic and/or teratogenic, there must be an effect upon all residents near hospital incinerators (Gatrell and Lovett, 1992). The disposal of toxic waste creates a major pollution problem (Clark el al., 1982) and a potential for increased risk to human health (Neutra ,1983).

This chapter begins with the discussion of factors influencing human exposure and continues with health impacts of chemical substance. After that breast milk and dioxins are discussed. Finally, psychological and social impacts of hospital waste incineration are explained.

9.2 Baseline study

This study concerns the EIA of hospital waste incineration. The incineration of hospital waste is designed to remove from the environment as a whole, various forms of toxic, pathogenic and other harmful materials. It is a form of pollution control for specific forms of pollution from the solid waste produced by hospitals. As in all forms of pollution control the alleviation of environmental problems in one location can produce problems in another location. An Environmental Impact Statement followed by an Environmental Impact Assessment of a new hospital waste incinerator may help to identify the project's impact on the environment. An EIA may even demonstrate that such a project is not required (see chapter 10).

Municipal or hospital incinerators produce some beneficial materials and these can be considered as useful by-products of incinerators. Energy from the combustion of wastes can produce electricity, and organic wastes can be recycled or converted to refuse-derived fuel for the production of energy.

9.2.1 Factors influencing human exposure

In this part of the chapter I will discuss the factors and pathways important in potential human exposure to contaminants from stack emission or ash residue and their effects on the human body. Health impact is quantitatively defined by different levels of physiological response and the affected population size. The most widely publicised link between incineration and ill-health relates to the Re-chem Plants in Pontypool and Bonnybridge. Among children born in the vicinity of the two plants, cases of congenital eye malformations have been reported in national newspapers. These defects include the absence of an eye (anophthalmus) and reduction in the size of an eye (microphthalmus). Official studies have been conducted by the Welsh and Scottish Offices and neither of them found any evidence to support the assertion of increased incidence of malformations in the vicinity of the Re-chem

Plants. In fact, the Welsh Office reported over a ten year period (1974-1983) on cases of eye malformation in Torfaen District, within which the Pontypool Plant is located. (Welsh Office, 1985). This is in contradiction to the cases identified and documented by the press. The variation may be due to the fact that genuine cases might not have been registered with the Office of Population Censuses and Surveys, which is the main source of Government reporting. In some parts of the UK (Birmingham for instance) there are local registers of congenital malformations and comparisons of these data with those from the Office of Population Censuses and Surveys indicates the latter to be of ambiguous quality when some classes of malformation are considered (Gatrell, 1990). There is a health survey of 2039 persons in 606 households situated near a hazardous waste disposal site in California, USA. By comparison with a reference community it was possible to assess whether rates of adverse health outcomes were increased among persons living near the site surveyed. Medical records of reported cancers and pregnancies, and birth and death certificates and a household questionnaire were used. Outcomes of the study showed that rate ratios were greater than 1.5 for 5 of 19 reported diseases, for example asthma, bronchitis, angina pectoris, ear infections and skin rashes. In contrast the survey areas appeared similar with respect to mortality, cancer incidence and pregnancy results. Prevalence odds ratios for 23 symptoms were uniformly greater than 1.0 and 8 symptoms had odds ratios greater than 1.5. These were blurred vision, daily coughing for more than a month, frequent diarrhoea, vomiting, frequent urination, pain in ears and unsteady walking (Baker el al., 1988). Critical reviews of 29 investigations of the health of a population living near to chemical waste disposal sites have confirmed that, with one exception, evidence is weak for a causal association between the occurrence of disease and vicinity to waste disposal sites. This concept does not mean, the investigators note, that such effects might not exist, or that positive results were caused by pollution escaping from the sites (Grisham , 1986). The two important pathways for human exposure to toxic substances from hospital incinerators are direct and indirect:-

a. Direct environmental impact

Inhalation exposure arising from emissions from incinerators in general and hospital incinerators in particular involves only one environmental medium, the air. For example dioxin, sulphur oxides, nitrogen oxides and other contaminants are emitted into the air,and then are spread as they travel downwind to a point where they may be directly inhaled. Tables 9.2.1 and 9.2.2 summarize the estimated annual cancer incidence and maximum individual lifetime cancer risk resulting from direct exposure to the stacks of municipal waste incinerators. In the tables, the annual incidence and maximum individual lifetime cancer

Table 9.2.1 Estimated USA cancer risk from direct inhalation exposure to emissions under baseline control scenario

Population of Municipal Waste Combustors	Organics [a]		Metals [b]		Combined	
	Ann. Incid.[c]	Max. Indiv.[d]	Ann. Incid.	Max. Indiv.	Ann. Incid.	Max. Indiv.
Existing Sources (1985)						
Massburn (Non-heat)	1.3 - 30	10^{-4} - 10^{-3}	.2	10^{-5}	1.5 - 30	10^{-4} - 10^{-3}
Massburn (Heat Rec)	.2 - 4	10^{-4} - 10^{-3}	.04	10^{-4}	.2 - 4	10^{-4} - 10^{-3}
RDF	.1 - 3	10^{-5} - 10^{-3}	.2	10^{-5}	.3 - 3.2	10^{-5} - 10^{-3}
Moduiar	.0008 - .01	10^{-6} - 10^{-4}	.01	10^{-4}	.01 - .02	10^{-4} - 10^{-4}
Total estimated risk from existing sources (Rounded)[e]	2 - 40	10^{-4} - 10^{-3}	.5	10^{-4}	2 - 40	10^{-4} - 10^{-3}
Projected Sources (1993)						
Massburn (Heat Rec)	.3 - 7	10^{-6} - 10^{-5}	.3	10^{-6}	.6 - 7.3	10^{-6} - 10^{-5}
RDF	.8 - 14.2	10^{-5} - 10^{-4}	.1	10^{-6}	.9 - 14.3	10^{-5} - 10^{-4}
Modular	.04 - .9	10^{-6} - 10^{-5}	.01	10^{-6}	.05 - .9	10^{-6} - 10^{-5}
Total estimated risk from projected sources (Rounded)[e]	1 - 20	10^{-5} - 10^{-4}	.4	10^{-6}	2 - 20	10^{-5} - 10^{-4}
Combined total (Rounded)[e]	3 - 60	10^{-4} - 10^{-3}	.9	10^{-4}	4 - 60	10^{-4} - 10^{-3}

a. CDD/CDF, chlorophenols, chlorobenzenes, formaldehyde, PCB, PAH. Organic emissions are based on assumed 20% control efficiency for both existing and projected source air pollution control equipment.
b. Arsenic, beryllium, cadmium, chromium +6. Metal emissions are based on estimated efficiency for installed air pollution control equipment for existing facilities, and a 99% efficient ESP for projected facilities.
c. Annual incidence is the aggregate risk of cancer cases per year in population within 50 Km of all municipal waste combustors in the US.
d. Maximum individual risk is the probability that a person exposed to the highest modeled concentration of pollutants from a municipal waste combustor to which anyone is exposed will develop cancer over a 70-year lifespan.
e. Apparent errors in total are due to intentional rounding to one significant figure.
Source: EPA, 1987.

Table 9.2.2 Impact of the application of dry scrubber/fabric filter control, devices on the estimated USA cancer risk from direct inhalation exposure to emissions

Population of Municipal Waste Combustors	Organics [a]		Metals [b]		Combined	
	Ann. Incid.[c]	Max. Indiv.[d]	Ann. Incid.	Max. Indiv.	Ann. Incid.	Max. Indiv.
Existing Sources (1985)						
Massburn (Non-heat)	.08 - 1.9	10^{-5} - 10^{-4}	.05	10^{-6}	.1 - 2	10^{-5} - 10^{-4}
Massburn (Heat Rec)	.01 - .3	10^{-5} - 10^{-4}	.01	10^{-6}	.02 - .3	10^{-5} - 10^{-4}
RDF	.01 - .2	10^{-6} - 10^{-5}	.03	10^{-6}	.04 - .2	10^{-6} - 10^{-5}
Modular	<.00001	10^{-7} - 10^{-6}	.001	10^{-6}	.001	10^{-6} - 10^{-6}
Total estimated risk from existing sources (Rounded)[e]	.1 - 2.4	10^{-5} - 10^{-4}	.1	10^{-6}	.2 - 2.5	10^{-5} - 10^{-4}
Projected Sources (1993)						
Massburn (Heat Rec)	.02 - .4	10^{-7} - 10^{-6}	.2	10^{-6}	.2 - .6	10^{-6} - 10^{-6}
RDF	.05 - .09	10^{-6} - 10^{-5}	.04	10^{-6}	0.09 - 0.9	10^{-6} - 10^{-5}
Modular	.002 - .04	10^{-7} - 10^{-6}	.001	10^{-6}	.003 - .03	10^{-7} - 10^{-6}
Total estimated risk from projected sources (Rounded)[e]	0.07 - 1.3	10^{-6} - 10^{-5}	.2	10^{-6}	0.3 - 1.5	10^{-6} - 10^{-5}
Combined total (Rounded)[e]	.2 - 4	10^{-5} - 10^{-4}	.3	10^{-6}	.5 - 4.5	10^{-5} - 10^{-4}

a. CDDs/CDFs, chlorophenols, chlorobenzenes, formaldehyde, PCB, PAH. Organic emissions are based on 99.5% control efficiency for dry scrubber/ fabric filter controls.
b. Arsenic, beryllium, cadmium, chromium +6. Metal emissions are based on 95% control efficiency for dry scrubber/ fabric filler controls.
c. Annual incidence is the aggregate risk of cancer per year in population within 50 Km of all municipal waste combustors in the US.
d. Maximum individual risk is the probability that a person exposed to the highest modeled concentration of pollutants from a municipal waste combustors to which anyone is exposed will develop cancer over a 70-year lifespan.
e. Apparent errors in total are due to intentional rounding to one significant figure.
Source: EPA, 1987.

risk estimates are desegregated by control scenario, existing and projected combustor populations,incinerator technology, and pollutant class (organic or metals). Also shown are the annual cancer incidence and maximum individual risk estimates contributed by pollutant classes and by category of municipal waste incinerator design for existing combustors. The mass burn non heat recovery category is associated with the highest risk, and for projected sources, the Refuse-Derived Fuel units appear to pose the highest risk (EPA, 1987).

b. Indirect environmental impact

Analysis of samples from the vicinity of stack emissions or ash residues have revealed a variety of chemical waste constituents which have been released and have migrated into the atmosphere, soil, surface water and ground water. The most important potential for health effects is believed to be associated with organic chemical contamination of ground waters used for drinking water supplies (Washburn, et al., 1989). A model of human exposure to air, water, and soil are outlined by the author in Figure 9.2.1. Stern conducted a study to assess the potential for adverse health effects resulting from neighbourhood exposure to soil and dust from a municipal incinerator ash landfill site, which received ash from a incinerator from 1954-1973. Soil was sampled for 10 heavy metals, polychlorinated dibenzodioxins, polychlorinated debenzofurnas, 2,3,7,8-

tetrachlorodioxin and furan congeners, polychlorinated biphenyl, and polycyclic aromatic hydrocarbons. The outcomes of soil analysis and modelling indicates children are exposed to lead levels above that currently defined as cases of lead poisoning. The potential for health effects resulting from exposure to other substances measured in the soil on this site is considered to be small, and no significant increased cancer risk is expected (Stern et al., 1989).

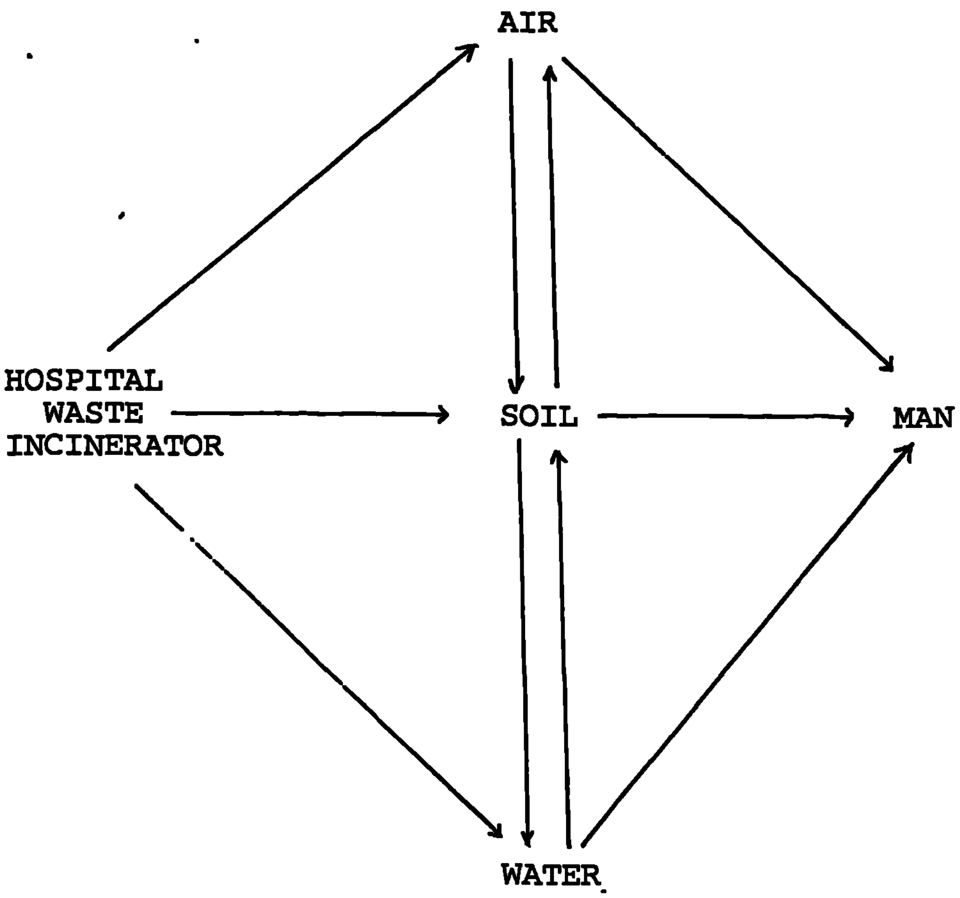


Figure 9.2.1 Effect of Exposure from Incinerator Installation on Man.

1. Impact on water

Ground water is recharged by rainfall and inputs from surface waters into the aquifer. The route of ground water flow is determined by the hydraulic gradients. Therefore, where ash residues have been disposed of in landfills, there is potential for their release from the disposal site and subsequent escape into ground water or into surface waters and subsequently into ground water. Some ash residue disposal sites are located sufficiently near water bodies for hazardous wastes to directly enter the surface water by surface run off (Washburn et al., 1989).

2. Impact on soil

Toxic substances from ash residue, such as the heavy metals, lead, mercury and cadmium can persist in the ground for a very long time. There have been some incidents which show the dangers to the public. Some of the hazardous wastes at chemical disposal sites will readily attach to soil particles (Chiou et al.,1979; Kenaga and Goring, 1980). Man is then exposed to soil-bound hazardous wastes by direct contact with the ash residue, via inhalation or skin contact of particles carried from the site by surface waters or wind. In many places where a population is near to a disposal site and where ground water is not used as a drinking water resource, inhalation of wind-borne particles could be a major route of contact with hazardous waste compounds(Johns Hopkins University, 1981).

3. Impact on air

Although hospital incinerators can reduce in volume and destroy hazardous or toxic wastes, they also generate undesirable air pollutants which require treatment procedures to be adopted to ensure clean discharges of combustion gases to the atmosphere. Hazardous wastes in landfills can also be carried upwards as gases escape through the soil and into the atmosphere (Shen, 1981, Thibodeaux, 1981). Some of the most important research on emissions of dioxin from municipal incinerators has been conducted at the Warren Springs laboratory (Wallin and Clayton, 1985).

Undesirable pollutants often include many chemicals, for example:-

i. Products of incomplete combustion (PICs)

These chemicals, which are often amongst the most toxic pollutants existing in stack emissions, are produced when organic compounds recombine in the post incineration zone of the incinerator. Many forms of Polychlorinated Dibenzo-p-dioxin (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) are amongst the most highly toxic compounds known to humans, and have been found to bioaccumulate in terrestrial animals (Firgerio 1978) and fish (Stalling et al., 1983).

ii. Hydrogen chloride (HCl) and other halogens

Halogenated organic substances when incinerated completely will usually produce hydrochloric acid (HCl) and chlorine (Cl_2) gases depending on the incineration conditions. If there is a sufficient source of hydrogen in the waste and incineration is at or near stoichiometric condition, about 65 percent of refuse chlorine will be converted to HCl (Hackman, 1978). A 1980 test of a California pathological waste incinerator burning 2.86 Kg/h of hospital waste, indicated an average HCl emission of 1120 ppm for test runs (ECE group Ltd., 1984). Dust samples from 18 German hospital incinerators carried up to 12.9 percent chlorides. Many tests indicated that HCl emissions posed a potential health risk (Murnyak, 1982).

iii. Sulphur Dioxide (SO_2)

Sulphur dioxide , on entering the intercellular tissue, reacts with water to give sulphite ions. It is a colourless, nonflammable and nonexplosive gas that starts to be sensed at concentrations from 0.3 to 1.0 ppm in air. The major sources of sulphur dioxide pollution in the UK are power stations (71%), industry (15%), domestic (15%), commerce (4%), and other (5%). (Green. et al., 1988).

Increasing concern over sulphur emissions has resulted in a drive to maintain all sources at as low a level as is possible to achieve. In the UK sulphur emissions have fallen, largely due to changes in domestic and industrial fuel use patterns (Bromley, 1985). Sulphur dioxide gas acts on the human respiratory system; it can cause irritation and increase the resistance of the airway to gas exchange although it is itself readily soluble and is removed in the upper part of the airway to the lung, where it combines with particles and aerosols (Clark, 1979).

iv. Nitrogen Dioxides (NO_2)

In incinerator systems, predominantly oxides of nitrogen are produced due to kinetic limitations in the oxidation of NO to NO_2. The emission of oxides of nitrogen is related to the temperature achieved by incinerators. As compared to other incineration processes, hospital incinerators achieve relatively low temperatures, therefore low NO_2 emissions (Hangebrauch, 1964).

This gas arises from the incineration of waste. It is readily soluble in water, and tends to attack recently matured leaves causing the problem of acid rain (Bromley, J. 1985). Some (contested) experiments state that there is an immediate effect on bronchitis and asthmatics, leading to respiratory resistance (Clark, 1979). NO_2 acts as an acute irritant and in equal concentrations is more injurious than NO which reduces the oxygen carrying capacity of the blood. It increases bronchitis in 2 to 3 year old children, and has been observed at concentrations below 0.01 ppm. Adverse health effects for short time exposure occur at a concentration of more than 940 ug/m^3 (0.5 ppm). The WHO suggested a one hour maximum of 190-320 ug/m_3 (0.10-0.17 ppm) of NO_2 which is not to be exceeded more than once per month.

v. Trace metals and their complexes

Laboratory researches can supply information under controlled conditions on the effect of pollutants on materials, plants, animals and to a limited extent, on humans. According to the EPA (1986) there are metals, Arsenic, Cadmium, Chromium, Iron, Manganese, Nickel and Lead in the refuse of hospital incinerators. Lead is the most prevalent heavy metal pollutant in the air. It has been indicated experimentally that at least 20% of inhaled lead can be absorbed. Inhaled lead is one contribution to the body's burden of lead which predominantly comes from ingestion. The acute effects of lead poisoning on human health include irritability, anaemia, miscarriage and, in children, defects of the nervous system including mental retardation, cerebral palsy and atrophy of the optic nerve. (EPA, 1986).

vi. Particulate matter

Particulate matter includes both liquids and solids such as smoke, dust, condensed fumes and mist. The hospital incinerator may emit a variety of particulate matter. Numerous studies have demonstrated a correlation with particulate and sulphur dioxide levels because these pollutants cause respiratory tract disorders in both adults and children (Lave, 1977). Experiments with rodents suggest that they are potent teratogens (Fletcher, 1985) but indications about human health are not completely clear. (EPA, 1981)

9.2.2 Health impacts of chemical substances

The potential for adverse health effects on the residents close to hazardous waste disposal sites may involve any organ of the body or any of the vital physiological functions. The effects would depend upon the specific chemical, the characteristics of the individual such as age, sex, and genetic make-up, the metabolism of the chemical and the contribution of other variables such as personal habits and prevalence of other diseases. Health effects of primary concern to exposed residents at disposal sites include genetic defects, cancer, congenital anomalies, alterations of immunobiological homeostasis, reproductive abnormalities and disorders of the central nervous system and behaviour. (Schaumburg et al., 1983; WHO, 1982; Shepard, 1983). Some emission from chimneys of hospital waste incinerators are outlined by the author in figure 9.2.2.

Figure 9.2.2 Possibile emissions from chimneys of hospital waste incinerators and hazardous potentials effects.

Substance & Source	Important effect
Chimney:	
Arsenic	Integument (skin) central nervous system.
Cadmium	Male and female infertility, development disabilities low birth weight.
Nickel	Skin irritant and contact allergen,
Asthma	Lung and respiratory tract
neoplasia.	
Lead	Loss of weight, Central nervous system Anaemia, Kidney, Lung.
Dioxins	Eyes and respiratory, haematuria, Skin, Liver, Corner.
Ethylene	Paralysis, Malfunction of heart.
Hydrochloric acid	Conjunctivitis, Corneal necrosis, irritation of skin and nephritis (inflammation of the kidney:
Discharge air stream, Post-incineration residue	
Sulphur dioxide	Conjunctivitis, corneal necrosis, bronchitis, burning skin.
Nitrogen dioxide	Respiratory, central nervous system, Circulatory.
Pathogens & Virus	Depend to waste
Ethane	Narcosis (paralysis)
Propane	Paralysis by inhalation of concentrated gas.
Carbon monoxide	Headache, dizziness and systemic pain.

9.2.3 Liver injury by chemical materials

A typical form of health injury is caused by damage to the liver. Its injury is in the form of the accumulation of fatty deposits and hypertrophy of the endoplasmic reticulum and may result from exposure to many chemicals. The liver is a primary site for biotransformation of chemicals as well as a target for the accumulation of toxins. Farber (1980) studied the interaction between the chemical metabolites and hypothecates which induce biochemical changes and convert them into "preneoplastic" cells (Farber, 1980).

9.2.4 Carcinogenic Human Health Effects

Cancer is a disease that has occurred in humans since prehistoric time and the causes of cancer have been a topic of increasing concern. Approximately two centuries ago it was detected that chimney sweeps, exposed to smoke from the burning of coal and wood, had a high incidence of scrotal skin cancer. This finding led to a requirement for chimney sweeps to bath weekly and is recognized as one of the first public health measures taken to prevent cancer (WHO, 1982).

A possible cause of cancer from incineration emissions is dioxin. Unfortunately literature on exposure to dioxin is poor as the research began only in the 1970s. Dioxin is ranked as the most potent carcinogen studied by the

Environmental Protection Agency. The first study which indicated a link between dioxin exposure and cancer, was a report from the former West Germany (Lundwigshafen) conducted into the incidence of cancer among workers exposed to dioxin in an industrial explosion (Yanchinski, 1989). The result indicated that mortality due to cancer of the trachea, larynx, bronchus and lung among these workers was statistically in excess of expected numbers. Polychlorinated dioxins are emitted from incinerators and other incineration processes in which carbon sources and chlorine containing materials are burned simultaneously (Department of the Environment, 1989). There are many chemicals which result from the recombination of the products of incomplete combustion and their composition varies with the proportion of the constituents of the original waste which remains unburnt. (Erickson et al., 1989; Trenholm et al., 1983).

The public perception of polychlorinated dioxin has been formed from two sources. The exposure of the Vietnamese population and US armed forces personnel to Agent Orange, the herbicide 2,4,5-T which was heavily contaminated with 2,3,7,8-TCDD during defoliation operations in Vietnam was one. The second was in 1976 after an incident at Seveso, in Italy, when a runaway reaction in a trichlorophenol plant released 12 Kil ogrammes of 2,3,7,8-TCDD over the surrounding countryside, causing 134 people to suffer from chloracne, the familiar symptom of human exposure to dioxin. That incident resulted in dioxin levels in the soil and air high enough to require evacuation of the public.

Dioxin is persistent in water and is not easily degraded by sunlight or microorganisms, and is believed to accumulate rapidly in fish, it is causing increasing public concern about its discharge to escalate. It has also begun to appear in combustion products from waste incinerators and the vicinity of dump sites. PCBs and dioxin levels higher than the US National Institute for Occupational Safety and Health recommended exposure limit were found in 74% and 92% respectively, of samples of dust taken from around the grounds of an American incineration facility (Bryant et al., 1989).

9.2.5 Breast Milk and Dioxins

Dioxin and furans have been detected in human milk samples obtained in several countries. Over the last decade research in the USA and Europe shows that adipose tissue and human breast milk have been contaminated with PCDDs and PCDFs (Schecter, et al., 1985; Ryan et al., 1985). One source of these materials in the environment is municipal waste or hospital waste incineration. The breast milk content of polychlorinated dibenzo-p-dioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) has been found to be unexpectedly high (Commoner, 1985) It is a considerable threat to public health.

9.2.6 Impacts of individual pollutants on breathing

Air pollution is truly a global public health emergency. United Nations statistics show that more than one billion people - a fifth of humanity-live in areas where the air is not suitable to breathe (French, 1990). Concern is growing around the world about the health problem posed by less common but extremely harmful airborne toxic chemicals such as benzene, vinyl chloride and other volatile organic chemicals produced by factories and automobiles. These chemicals can cause a variety of illnesses, for instance asthma and obstructive pulmonary disease. The term obstructive pulmonary disease is meant to encompass both pulmonary emphysema and chronic bronchitis (Schrenk, 1949; McCarroll, 1966). Some of the symptom complexes designated "asthma" have been related to community air pollution. The general role of pollens and dust in the precipitation of asthmatic attacks is well known and need not be discussed in this study. This is covered in the work of Spicer and his colleagues (McCabe, 1952) and the world wide experience reviewed by Booth and her co-workers (Booth, 1965).

Some of the most toxic pollutants are insecticides applied by spraying from the air. 2-4 Dichlorophenoxyacetic acid is an extremely effective pesticide, but it can also damage sensitive plants and may be harmful to human health. Occasionally some of these compounds are contaminated with highly toxic chlorinated dioxins. The most hazardous of these is 2,3,7,8-tetrachlorodibenzo-p-dioxin (Barstad ,1978).

9.2.7 Psychological and Social Impacts of Hospital Solid Waste Incineration

This section concerns the psychological and social aspects of a waste disposal site in general and hospital solid waste incineration in particular. No one wants hospital wastes; but the wastes cannot just be thrown away. The Public does not want to live near a waste disposal site. Although the wastes have to be placed somewhere, no place seems acceptable to everyone. Hospital incinerators are just one of many projects which need to be accepted regionally, but are objectionable to people who must live near them. Greenberg and Anderson (1984) cited studies showing that a community that gets a Locally Unwanted Land Use (LULU) is perceived as an undesirable place to live. For instance, about 200 persons in Erie County, Pennsylvania (USA) were asked their reaction to the siting of a municipal solid waste facility near their homes. Less than six percent were willing to accept the facility, and six percent undecided. Almost two-thirds were clearly opposed, and one-fourth would fight against the proposal unless they could be convinced that the landfill would be carefully operated.

The most significant psychological and social aspects to be studied are the stresses and conflicts experienced by people living in what they feel to be conditions of risk. The methods used for the investigating of community concerns and the way in which these are managed also have an important influence on the psychological and social impact experienced by the public of living near a waste disposal site (Anon, 1988). In other words, proposed new hospital incinerator facilities typically encounter intense public opposition. At the heart of such opposition lies fear, fear of being the victim of another environmental disaster.

Sources of human stress directly related to urban settings are well known and include air pollution, intense noise, ambiguity and complexity, safety problems, living in a situation of perceived risk as well as many other factors (Anon, 1988).

The idea that stress leads to illness has a long history. The effects of the stress linked with most life events and general social factors on the health and well-being of individuals have been widely investigated by researchers. (Leshan, 1959 ; Levi,L. 1971 ; Gunderson and

Rahe, 1974. ; .Depue and Monroe, 1986). In the early 20th century, Sir William Osler suggested that stress contributed to the development of heart disease.

The adverse effects of stress on physical health and emotional well-being are now generally recognized, but there is as yet little agreement on the definition of stress (Selye, 1976). Stress is a word derived from Latin. It was used popularly in the Seventeenth century to mean "affliction, hardship, adversity or straits". In the Eighteenth and Nineteenth centuries it was used to denote "pressure, force, strain or strong effort". In recent years, considerable amount of public and professional interest has been focused on the relationship between stress and physical and mental health. Research has demonstrated associations between stress and disease and has suggested the importance of stressful factors and life events.

Dohrenwend and his colleague (1981) think of life stress processes as consisting of three main structural components.

1. The first is the stressor component. These events can range from extreme situations such as combat and natural disasters to the more usual life events that most of us experience at one time or another.
2. The second major component is the ongoing social

situation.

3. The third component consists of personal dispositions. Dohrenwend and his colleague have suggested five alternative models portraying different ways in which these three components of life stress processes may be related to each other and to adverse changes in health. They have called these models victimization, vulnerability, additive burden, chronic burden and proneness (Dohrenwend, 1981). These models are summarized in Figure 9.2.2

It is very difficult or sometimes impossible to determine the cause and effect relationship between increased stress and many of the health effects reported at waste disposal sites, although it is important to take this into consideration. A report to the Housing Committee of Knowsley Metropolitan Borough Council showed that premature death was a startling 15 per cent above the national average. According to the report, between 1975 and 1984, of the 5125 deaths recorded, 1074 (20.1%) were prematurely caused by just two preventable diseases, cancer and heart disease. Despite the lack of literature on stress related illness, it would be valid to regard Knowsley Metropolitan Borough as an area of high psychosocial stress, caused to a great extent by the prevailing socio-economic circumstances. It would also be true to say that stress is a contributory factor in most illnesses and possibly a precursor of premature death in Knowsley.

Figure 9.2.3. Five hypotheses about the life stress process

A

Victimization

Stressful life events ------------> Psychopathology

B

Vulnerability

Social situation

Stressful life events --------------> Psychopathology

Personal disposition

C

Additive Burden

Social situation

Stressful life events --------------> Psychopathology

Personal disposition

D

Chronic Burden

Social situation

Personal dispositions

Psychopathology

E

Proneness

Prior psychopathology ----> Stressful life events ---> Exacerbation of Psychopathology

Source: Dohrenwend, 1981.

CHAPTER TEN

EIA AND HOSPITAL WASTE INCINERATORS

10.1 Introduction

In order to investigate the application of EIA methods to hospital waste incineration I combined my investigations at Kirkby and Iran with information taken from the literature. This information has formed the bulk of my thesis.

As described in Chapter Five there are many methods for making an environmental impact assessment. Some procedures are qualitative and others operate quantitatively. Also, some methods are general and some others are specific and based upon particular aspects or conditions. Before choosing a specific EIA method for the installation of a hospital incinerator, it is useful to subdivide the implementation of an EIA into activities. These are impact identification, prediction, interpretation, communication, monitoring and mitigation. It is important to bear in mind that not all EIA methods cover all these activities. Some methods cover only a few while others can be used for almost all the activities mentioned above. Choosing a method depends upon the particular demands of the user and type of project being undertaken. For this reason the main methods are critically reviewed as follows:-

10.2 Critical review of the methods

Ad hoc (See Chapter 5).

These methods are widely used by USA Federal Agencies after the establishment of NEPA (see Chapter 5, 5.8-a). Although this approach assists in identification of environmental impact it does not address secondary or indirect impacts. It gives no guidance for the communication of results, or on their interpretation. Also it does not provide a helpful format for impact assessment. Because of these limitations I believe this method is not suitable for application to the installation of a hospital incinerator. Although it may from an important first step towards defining other procedures.

Checklists (See Chapter 5).

These show a particular list of environmental parameters to be investigated for possible impacts (see Chapter 5, 5.8-b). Amadio and Carlo (1990) reported on a checklist approach for assessing the environmental impact of a hospital waste incinerator in Rome. The different kinds of checklists have various advantages and disadvantages but they all have a great drawback. They concentrate only on the negative side of the impact phenomenon. Because they do not identify either the positive environmental effects of a proposed installation or the ways in which negative effects may be reduced I do not believe that checklists are useful in the environmental impact assessments of hospital incinerators.

<u>The Overlay Method</u> (See Chapter 5)

This method was developed by McHarg (1968). It is a well developed techniques for planning landscape and architecture. He used a series of overlaid maps of environmental concerns or land features to discriminate between design. alternatives (See Chapter 5, 5.8-c). The technique relies upon a set of a project area's environmental characteristics (Physical, social, ecological, aesthetic). This method is used to identify, predict and determine the relative significance of impacts to place them in a geographical reference frame. Although this method is comprehensive in its identification of impacts, it is not capable of reflecting the possibility of second order interactions. Experience with this method shows that it is very helpful in assessing alternative routes for linear developments, for example highways, pipelines and transmission . This approach is very good for indicating the particular dimension of impacts, but it is less effective in dealing with other impact characteristics such as probability (Bisset, 1987). In relation to hospital waste incinerators the use of overlays is of limited value as the main activity of an incinerator is at a fixed point. Nevertheless the use of the McHarg method as part of a wider EIA may be valuable. For instance in evaluating the linear impact of transport systems taking waste to and by-products from a potential site. In addition,the McHarg technique may be applicable in helping to identify the linear impacts of the down-wind effects of aerial pollution. The method could be applied to different aspects of the linear effects of aerial pollution in relation to the wider area.

<u>The Networks Method</u> (See Chapter 5)

This approach helps in the identification of indirect impacts (see Chapter 5, 5.8-e). It consists of a series of cause/effect impact relationships. The Networks approach is useful in identifying indirect impacts, but has extensive resource needs. It does not provide a standard means of deciding on the relative importance of differing 'cause-condition-effect' pathways. This method traces out higher order effects, therefore it cannot identify all those which could happen. Hence, the Networks method is not suitable for a hospital incinerator. Although the Networks Method is helpful in organizing information and deciding on mitigation measures, it fails to indicate a means for going beyond biological, physical and chemical impacts to give quantitative values. Values which could be very important at Kirkby and in Iran for example. Literature shows this method has been applied to proposed commercial, transportation and residential projects (Sorensen, 1971).

The Environmental Evaluation Systems

This method is based on a quantitative, accumulated index of 78 environmental parameters and 18 subcategories and four broad categories. They are:- ecology, environmental pollution, aesthetics and human interest. These methods do not have guidelines which enable impacts to be directly compared for relative importance (See Chapter 5, 5.8-f). They do not deal with risk and the temporal aspect is also limited. Other aspects which characterize these methods are their complexity which results in extensive data and manpower requirements. Also the features of index methods make them politically charged (Clark, et al., 1978). Therefore, these methods are not suitable for hospital incinerators.

It is clear from what has been explained above that time and manpower . required to obtain the huge amounts of data needed for this approach. One of the reasons that EIA is expensive in a country like Iran (a developing country) is the limitation of technical data bases upon which the hospital waste incinerator project's impacts are to be based. As a result, a large amount of baseline data must be collected which is not only expensive but may also be impractical.

Models

According to Munn (1975), Models in EIS are simplified representations of the actual, complex systems which may be affected by a project. Simulation models can produce a helpful tool for formulating and assessing the likely impact of alternative strategies before to the preparation of land-use plans and policies (see Chapter 5, 5.8-g). These methods are also very useful management tools to be used after a project becomes operational. They can help in many of the EIA activities, except that of impact interpretation and evaluation (Bisset, 1987). Unfortunately the information collected from models is largely misunderstood, and sometimes misinterpreted, specifically by individuals not familiar with the technical features of the models. In my opinion this method is not suitable for hospital incinerators because it is unable to identify first-order impacts. It does not rank preferences for alternatives and it does not incorporate value judgments. Such methods need expert interpretation and are very time consuming. For these reasons it is not suitable for Iran and other developing countries. Also it is not right for Kirkby because it is not comprehensive enough.

PADC method

The PADC Method was created for use in the UK by the Government, developers and public (see Chapter 5, 5.8-k). The PADC Manual explicitly considers the magnitude, prevalence, risk and mitigation. It is flexible but it does not consider importance or alternatives. Therefore I think it is not suitable for hospital waste incinerators and so is not suitable for the Kirkby project. Also as it was created for use in a developed country where more experts are available it is not suitable from use in Iran.

Leopold Matrix

The Matrix is used to identify impacts by systematically checking each development activity against each environmental variable to identify whether an impact is likely to happen. All matrices include two checklists, one horizontal and the other vertical (see Chapter 5, 5.8-c). Matrix based methods originated from the development of the simple interaction matrix for the USA Geological survey developed by Leopold et al., 1971. According to Clark et al., 1978, the initial Leopold Matrix was divided into five different categories, which were the descriptive, symbolised, characterised, numerical and combined matrix. This method was used for airport siting and development and water resource control. The Matrix Modified versions include fewer levels of magnitude and importance. This approach does not recognize probabilistic factors.

Although, very high resource demands are involved in information gathering for the matrix it is easy to construct, and it can serve as a focal point for analysis and information collecting during the initial stage of an environmental assessment.

Conclusion

Taking the information given above on the application of EIA methods to hospital waste incineration I constructed a matrix (Table 10.2.1) to identify the strengths and weaknesses of each technique. This matrix confirms the statement made in Chapter 5 that no one method is able to meet all EIA criteria as table 10.2.1 illustrates. The Leopold Matrix compared with other methods has major positive points in assessing impacts (11 cases). Thus, I selected the Leopold Matrix method for the assessment of impacts of the installation of a hospital incinerator.

A full description of the different environmental impacts of incinerators and their mitigation measures have been presented in Chapter 5 and earlier this chapter. This information came from a literature survey and case studies in Iran and Kirkby. This is shown in Table 10.2.2. This information helped the author to prepare three matrixes.

Table 10.2.1 Methods comparison for An EIA.

Methods / Activities	Ad Hoc	Checklist	Networks	Evalution system	Models	PADC method	Overlaes	Leopold Matrix
Easy to understand	x	x				x	x	x
Identifies linear impacts						x	x	
Identifies mitigation methods					x	x		
Does not need techenology								x
Limited use of skilled manpower	x	x				x	x	x
Identifies health risks			x	x	x	x		
Identifies natural impact								x
Long term					x			x
Identifies important impact								x
Monitoring			x		x			
Positive and negative impacts			x	x	x			x
Area Considered			x	x		x		x
Construction				x		x		x
Physical & Biological	x	x	x	x	x	x	x	x
Socio-economic	x	x	x	x	x	x	x	x

Table 10.2.2 Possible Impacts and their Mitigation

Process	Predicted Hazard	Risks	Mitigative Measures
Transportation of waste	Leakage of infectious material	Infection	Proper Handling + Management
Incineration process	1. Combustion treat. 2. Ash (fly + bottom) Visibility 3. Gaseous emission 4. Noise	Incomplete combustion Respiratory. Crashes. Poisoning (livestock, fish, soil,water, agriculture). Mental health.	Appropriate technology + Methods + Management
Individual perceived risk	Stress due to worry about emissions	Depression + illness	Inform Community
Waste product disposal	Leakage	Infection + Disease	Constant monitoring

The next part of this chapter develops the use of a Leopold matrix in the application of EIA to hospital waste incinerators.

10.3 The application of Leopold's Matrix in the installation of a hospital Incinerator

Starting from the baseline study, the impact identification exercise was applied to the checklist of Figure 10.3.1 and produced a list of important issues for the socio-economic, physical and biological environments. These were combined with the different incinerating practices utilized in the literature and produced the matrices lay out of Figures 10.3.2, .10.3.3 and 10.3.4. These matrices are based on Leopold's matrix which will be used in the assessment of different impacts that may result from the installation of a hospital incinerator. I believe that this is the first time that Leopold's matrix has been used for the assessment of a hospital incinerator.

Figure 10.3.1 Checklist of the environmental Impacts of a hospital waste incinerator

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1. Physical & Biological Impact

a. Air pollution (Incinerator emission)
 i. Trace metal
 - Arsenic
 - Cadmium
 - Chromium
 - Iron
 - Manganese
 - Nickel
 - Lead
 ii. Polycyclic organic matter
 - Dioxins
 - Furans
 iii. Low molecular weight organic compounds
 - Ethane
 - Ethylene
 - Propane
 - Propylene
 - Trichlorotrifluo-roethane
 - Trichloroethylene
 v. Acid Gases
 - Hydrochloric acid
 - Sulphur dioxide
 - Nitrogen oxides
 iv. Others
 - Particulate matter
 - Carbon monoxide
 - Pathogens
 - Viruses
b. Water pollution
 - Surface water
 - Ground water
c. Soil contaminated
d. Terrestrial
e. Aquatic
f. Animals
g. Crops pollution
h. Food pollution
i. Traffic movements
j. Dust
k. noise
l. Odour
m. Bottom ash

2. Socio-Economic Impact

- Income for the city
- Psychopathology
- Employment

Figure 10.3.1 Continued

- Family stability
- People displacement
- Children
- Public health
- Community stability
- Elderly people
- Pregnant women
- Value of property
- Energy recovery
- The loss of trust
- The inversion of home
- A changed perception of one's control over the present and future

3. Human Health Impact

- Heritable defects
- Biologic principles mutation
- Skin rashes
- Central nervous system
- Liver
- Reproductive system and fetus
- Haematopoietic and Lymphatic system
- Lung and respiratory tract
- Carstrointestinal tract
- Cardiovascular system
- Cancer
- Ear infection
- Angina pectoris
- Bronchitis
- Asthma
- Vectors

10.3.1 Explanation of Matrix weighting

The justification which follows shows the argument behind the giving of numerical values for the magnitude of impact effects and their importance. The main aim of the Leopold matrix is the identification of impacts and determination of their magnitude and significance. For this purpose an interaction through a cause-effect relationship indicates the impact between the particular activities. As described in Chapter 5, the identified impacts are evaluated according to magnitude and importance on a scale of 1 to 10 (where 1-3 indicates the low effect, 4-7 shows the moderate impact and 8-10 indicates a large impact), the results are entered in the relevant cells in the matrix.

I have drawn up three Leopold matrixes covering the assessment of impacts on the physical and biological environment (Fig 10.3.2), the socio-economic environment (Fig 10.3.3) and human health (Fig 10.3.4) in Kirkby. The proposals for Kirkby are based on my own work and from discussions with colleagues and fellow postgraduates in the Environmental Resources Unit. The three matrixes contain more than five hundred cells for the identification of possible interactions. Limitations of space preclude a discussion of the reasons behind the selection of these cells and more so of the relative values of significance and magnitude allocated to each interaction. I have therefore selected several sample interactions to illustrate the considerations used in selecting cells and evaluating impacts.

a. Physical and Biological Environment. Kirkby (Figure 10.3.2)

Air quality can be affected by an incinerator in several ways. The important factors responsible for

Figure 10.3.2 the Leopold's matrix for assessment of impacts on the physical and biological environment. Kirkby

	Environments / Environmental Impacts / Incineration of Hospital waste	Physical & Biological Environment: Air pollution	Surface water Pollution	Ground water Pollution	Soil contamination	Flora and Founa	Crops contamination	Animal contamination	Food contamination
1	Planning								
	Construction of hospital incinerator	2/2			1/1	1/1			
2	Collection & Handling				1/1	1/1			
	Storage	3/1	1/1	1/1	1/1	2/1	1/1	1/1	2/1
	Transport	3/1	1/1		1/1	1/1	1/1		3/1
	Noise								
	Fire	3/2			2/1	3/1	2/1	1/1	3/1
	Explosion	3/2			2/1	3/1	2/1	1/1	3/1
	Acid Gases	5/3	3/2	3/2	2/1	3/2	2/1	3/2	2/2
	Pathogenic bacteria escape	6/3	3/1		1/1	2/2	3/1	3/2	3/1
	Arsenic	5/3	1/1		1/1	3/2	3/2	3/2	3/1
	Cadmium	3/2			1/1	3/1	2/1	3/1	1/1
	Manganese	3/2			1/1	3/1	2/1	3/1	1/1
	Nickel	3/2			1/1	3/1	2/1	3/1	1/1
	Lead	6/3			2/1	3/1	3/3	4/4	2/1
	Dioxins & Furans	7/4			1/1	2/2	3/1	3/2	2/1
	PICs	5/4			1/1	2/2	3/1	3/2	2/1
	Particulate matter	3/2	1/1	1/1	2/2	1/1	2/2	2/2	1/1
	Carbon monoxide	3/3					1/1		1/1
3	Ash landfill			3/2	5/5	3/3	1/1	1/1	1/1

deterioration of the air quality are pathogenic bacteria, arsenic, lead, dioxins, furans and ash for landfill.

The release of pathogenic bacteria through the chimney during the malfunctioning of the incineration process and also the transport and storage of the waste before incineration may lead to the spread of infectious diseases. Since the discharge would be through chimneys it would be dispersed to and affect a large area.

Regarding the literature in Chapter 9 and case studies in Iran and Kirkby Chapters 7 and 8, air pollution related to pathogenic escape is important. For these reasons I chose the cell which shows the interaction between air pollution and pathogenic bacteria escape from a hospital waste incineration project. Local people in Kirkby were asked to give, in their own words, their feelings about hospital incinerators, their replies were not very different. An example was:-

" I which to protest against the building of a hospital waste plant in the industrial estate of Kirkby. As someone who lives and works in the area which could be affected by emissions from the proposed plant I feel that the close proximity to the proposed site of housing, schools, hospitals and sports grounds, makes its location unsuitable. I am concerned over the possible ill health of my family from incinerator emissions especially in the case of breakdown or accidental emission of bacteria and toxic

gases from the plant."
This has been considered important and has been assigned a value of 3 in magnitude and 6 in importance.

Most of the laboratory waste from the hospital contains many chemicals such as arsenic which is disposed of through incineration. During the process it is not destroyed but released to the atmosphere through the chimney as well as to the soil by the disposal of ash. As explained earlier arsenic can cause harm to the central nervous system. Therefore, it is important and I have chosen this cell. Regarding the literature in Chapter 9, arsenic has human carcinogenic effects and systemic skin effects. It is usually an acute poison; inhalation or ingestion usually leads to chronic poisoning (see Table 9.2.1). Since this is also important and without any control it can cause harm to humans and the environment. Hence I have assigned a value of 3 to the magnitude and 5 to the importance. Even though the quantity of emission is low the effect is still high.

Another concern which has been highlighted recently is the lead emissions from hospital waste incinerators (see EPA, 1988b). That lead may be absorbed by those who live around the hospital waste incinerator. Epidemiological studies are an important source of information for assessing risk to human health and have produced much information about toxicity to humans of materials such as lead. It can create diseases such as pigment discoloration (blue-grey) and loss of weight (Grisham, 1986). Hence I chose this cell because of its significance impact. It was mentioned in Chapter 9 and could be repeated, lead and compounds are all cumulative poisons. It effects the human central nervous system. All workers should be tested periodically for lead in the urine and blood. The results from these tests should be discussed with a physician at least four times a year. Therefore lead was considered to be rare and assigned a magnitude of 3 but if lead is absorbed by Man it can be dangerous and hence was given an importance value of 6.

Failure to achieve satisfactory standards for the incineration process can result in some problems. For example incomplete combustion will fail to destroy the waste completely and therefore the danger will remain (see Chapter 3). Also this condition can lead to the formation of new substances, such as products of incomplete combustion (PICs). Hence, it is important and for this reason I chose this cell. As can seen from the literature in Chapter 3, products of incomplete combustion (PICs) in significant quantities can be damaging to the environment and human health. If a hospital waste incinerator is properly operated, PICs will not be released at levels that would be regarded as harmful. Hence, potential risk from PICs can be estimated in the same way as risk from other sources of hazard. Also some of the PICs could recombine to form other toxins such as a dioxins and furans. Therefore, I have assigned a value of 4 to the magnitude and 5 to the importance; even though the quantity of emission is low the effect is still high.

There were people concerned over the dioxins, furans and products of incomplete combustion (PICs) reported in the soil (see Chapter 9) in the vicinity of incinerators. Dioxins and furans are very dangerous and can create nausea and vomiting, headache and signs of irritation to eyes, skin and respiratory tract and human carcinogenicity (Grisham, 1986). Therefore it is harmful to health and very important, hence I chose this cell. The literature shows (see Chapter 9) polychlorinated dibenzodioxins (PCDD) changes to blood, liver damage, skin disorder, lung lesions, loss of weight and death. Also dioxins can cause cancer, reproductive failure, birth defects and reduced immunity. Also as regards perceived local community attitudes (see Chapters 7 and 8), the general impression was that the local people in Kirkby and Iran were opposed to the hospital waste incinerator proposal and were very concerned about dioxin. Their feelings about dioxin are as follows:-

"I would like to oppose the building of a hospital waste incinerator close my to house. A hospital waste incinerator will endanger the health of the local community as a result of poisonous emissions into the air of dioxins. I and my family are very concerned about dioxins which result from this project".

Hence the magnitude and importance for these substances are rated 4 and 7 respectively.

The ash from a hospital waste incinerator is typically disposed of in a landfill. According to EPA (1988c) studies have not been performed especially for hazardous waste incinerator ash. Assessment of risk from disposal in landfill is very difficult to separate from the risks associated with other substance in the landfill. Therefore the magnitude and significance are not rated.

b. Socio-economic environment. Kirkby (Figure 10.3.3)

The potential sources of positive impacts can include employment generation and expenditure of employees' salaries in the local economy. The proposal to install a hospital waste incinerator in Kirkby will provide permanent employment for twenty five person full time. However, not all these people will necessarily be local residents. It should be noted, twenty five jobs in Kirkby are not very important in comparison with the total population. As stated by Mr Mike Maguire, treasurer of KAPIT in the inquiry concerning a proposal to construct an incinerator on the Kirkby Industrial Estate in 25.9. 92. " As many people have already stated, Kirkby suffers from a high level of long term unemployment. ... Kirkby has at least double the national average for unemployment. ... The overall view is one of severe deprivation for large sections of the community, who have a daily struggle to make ends meet. That would be bad enough on it s own but when you combine it with the overall health picture within the town, the obstacles facing the community are even greater." He concluded that the advantage of employment provided by the project was outweighed by the disadvantage of possible health risks. Therefore the magnitude and importance are rated to be 1 and 1 for the construction phase of a hospital waste incinerator, 2 and 2 for collection and handling and for transport 2 and 2.

When a hospital incinerator is installed in a community, children are faced with almost the same health impacts as are adults. Although it is difficult to assume that they are affected in the same way as adults, it is clear that they are affected by the experience. Their stress comes largely from two sources. First, parental concern is passed along to them, as are the tensions due to parental stress. Second, children have a variety of experiences of their own involving direct impacts from waste sites, equal pressures, and the consequences of being taught to fear. The result is the sensitization of the child to the issues involved in toxic exposure.

The lifestyle and habit differences in children may make them more vulnerable to the impacts of hospital waste

Figure 10.3.3 the Leopold's matrix for assessment of impacts on the socio- economic environment. Kirkby

Environments		Socio-Economic Environment								
Incineration of Hospital waste	Environmental Impacts	Employment	Income for town	Immigration	Value of property	Family stability	Children	Pregnant women	Elderly people	Public health
1	Planning				5 \ 4					
	Construction of hospital incinerator	1 \ 1	1 \ 1	1 \ 1						2 \ 2
2	Collection & Handling	2 \ 2	2 \ 2				3 \ 1	4 \ 2	4 \ 1	1 \ 1
	Storage	2 \ 2			3 \ 2	1 \ 1	2 \ 1	1 \ 1	1 \ 1	1 \ 1
	Transport	2 \ 2	1 \ 1		1 \ 1	2 \ 1	1 \ 1	1 \ 1	1 \ 1	2 \ 2
	Noise					3 \ 2	3 \ 2	3 \ 2	2 \ 1	2 \ 2
	Fire			1 \ 1	3 \ 2		1 \ 1	1 \ 1	1 \ 1	1 \ 1
	Explosion			1 \ 1	4 \ 3		1 \ 1	1 \ 1	2 \ 1	2 \ 2
	Acid Gases				2 \ 2		3 \ 1	3 \ 1	3 \ 1	2 \ 1
	Pathogenic bacteria escape					3 \ 1	3 \ 2	4 \ 3	3 \ 2	5 \ 3
	Arsenic			1 \ 1	3 \ 2		5 \ 3	5 \ 4	5 \ 3	5 \ 3
	Cadmium					1 \ 1	3 \ 2	3 \ 4	3 \ 2	3 \ 2
	Manganese						2 \ 1	3 \ 2	2 \ 1	3 \ 2
	Nickel						2 \ 1	3 \ 2	2 \ 1	3 \ 2
	Lead			1 \ 1	2 \ 1	1 \ 1	6 \ 2	6 \ 2	6 \ 2	5 \ 3
	Dioxins & Furans			1 \ 1	2 \ 1	1 \ 1	7 \ 4	7 \ 2	6 \ 2	6 \ 4
	PICs			1 \ 1	2 \ 1	1 \ 1	6 \ 3	6 \ 4	6 \ 2	6 \ 4
	Particulate matter				3 \ 2		2 \ 1	3 \ 1	2 \ 1	3 \ 1
	carbon monoxide				1 \ 1		1 \ 1	1 \ 1	1 \ 1	1 \ 1
3	Ash landfill	2 \ 2	2 \ 2	1 \ 1						

incinerators. They like to pass a greater amount of time out of doors and play with soils and other substances, therefore may be more exposed to emissions from hospital waste incinerators. Hence they are more vulnerable. For these reasons the magnitude of arsenic is rated to be 4 and importance is assigned a moderate value of 7.

According to Smith, 1987:-

"Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) have been detected in human milk samples obtained in several countries. Possible sources include emissions from incineration of municipal waste in resource recovery facilities. A formula is presented for calculating the infant daily dose of dioxin equivalents from breast milk on the basis of the maternal daily intake. Application of the formula suggests that an infant breast-fed for 12 months would receive around 10% of the cumulative exposure dose per body weight that would be received by an adult with 50 years of exposure. Further analysis indicated that the contribution of dioxin equivalents from breast milk to an infant's body concentration at the end of 12 months of breast feeding would amount to 1.7 times the concentration in the mother."

Pregnancy is a time of many physiological changes in women. The pregnant women would be at considerably high risk. As mentioned in Chapter 9 (section 9.2.5), a particularly worrying aspect of dioxin pollution for women is its presence in breast milk. Therefore it is important and I chose this cell.

Dioxin has been linked with birth defects and also physiological changes in metabolism which may make pregnant women more vulnerable to the effects of exposure to dioxins. Hence the magnitude of dioxins for pregnant women is assigned to be low (2) and importance is rated to be 7.

Understanding both the magnitude and importance of a person's environmental interaction becomes even more important with increasing age. The decrease in the efficiency to metabolize foreign compounds, the reducing of reserve ability with age might all theoretically increase the vulnerability of elderly people to certain hospital waste incinerators. Therefore the magnitude of lead is rated to be low (2) but importance is high being assigned a value of 6.

c. Human health. Kirkby (Figure 10.3.4)

The plant is designed to process solid waste types generated by hospitals in the Merseyside area. Typically, these wastes include pathogens, toxic waste from the laboratories and wards and pharmaceutical waste (see Chapter 3). Typically the porters collect bags of waste from wards and transport them by truck to the hospital central collection for later transport to the hospital incinerator area. Therefore in this process there are many possibilities for puncture of the bags and other accidents which could contaminate the environment and Man.

The impact of hospital waste incinerator emissions for human health and the environment is not clear. Although, there is likely to be better data in future years as

Figure 10.3.4 the Leopold's matrix for assessment of impacts on the human health. Kirkby

Environments		Human health hazards							
Incineration of Hospital waste \ Environmental Impacts		Skin	Central nervous System	Liver	Reproductive system and fetus	Inherited defects	Lung and Respiratory tract	Eye irritation	Cardiovascular system
1	Planning		3/2						2/1
	Construction of hospital incinerator		3/2				2/1	2/1	
2	Collection & Handling	6/4	6/2		2/1		6/3	1/1	2/1
	Storage	3/1	5/3	1/1	3/2	3/1	5/4	2/1	3/3
	Transport	3/2	6/4	1/1	1/1		3/2	2/1	6/3
	Noise		2/1		3/1	3/1			2/1
	Fire	2/1	5/3				2/1	1/1	2/1
	Explosion	2/1	5/3			1/1	2/1	1/1	3/1
	Acid Gases	3/3	6/2	2/1	1/1	3/1	5/2	7/3	
	Pathogenic bacteria escape	4/3		3/3			5/3	2/1	2/1
	Arsenic	5/3	6/3	1/1	3/1		3/1	1/1	2/2
	Cadmium	1/1		4/4	2/1		3/2		
	Manganese	4/3		1/1					
	Nickel	4/1					5/3		3/3
	Lead		4/3		5/5				3/2
	Dioxins & Furans			6/2		3/2	5/3	5/3	5/3
	PICs			6/2		3/2	5/3	5/3	
	Particulate matter	4/4			3/1		5/4		
	carbon monoxide		4/3						2/1
3	Ash landfill				2/1	2/1			2/2

measures to monitor emissions improve, this should enable more accurate assessment of the character of the possible implications for human health. To estimate or evaluate the potential human health impacts correlated with hospital waste incinerator activity, we need first to assess the level of exposure to the hazardous material in the environment. Second, estimating the magnitude of the human dose based on hazardous substance concentrations in the environment may need the application of many assumptions with regard body weight, amount of dermal absorption, respiration rate, rate of incidental contaminated soil ingestion and rate of consumption of food and water.

In many situations (such as the hospital waste incinerator) emotional and psychological factors overemphasize the scientific measurements of exposure. We need a toxicological basis to compare the situation with the help of independent experts. In spite of this lack of information on hospital waste incinerators I have used toxicology data from other source (e.g Figure 9.3.1) to prepare the above matrix, hence, these values are my opinion only.

10.4 SWOT Analysis of the Leopold Matrix Method of Assessment.

A SWOT analysis considers the strengths, weaknesses, opportunities, and threats of an assessment.

a. Strengths

The chief strength of the Leopold Matrix approach for the environmental impact assessment of hospital waste incinerators lies in its ability to deal with the interpretation of the magnitude and significance of the impacts. This method involves procedures whereby impacts can be considered in terms of their relative magnitudes. It can indicate that a relationship exists between a hospital waste incinerator project action and its environmental impact. For example the Kirkby or the Ahwaz project.

The important strengths of this method for a hospital waste incinerator project are its potential comprehensiveness; its regard for an adequate base line study and its clear linkage of actions and environmental characteristics facilitating comparison of alternative projects.

The strength of this method in relation to hospital waste incinerators can be summarised in four factor as follows:-

1. The Leopold approach identifies impacts from a matrix of 100 project actions and 88 environmental characteristics and adapts them for hospital waste incinerator project use in Ahwaz and Kirkby.

2. This method uses a sensitive scale of 10 numerical values to clearly assess the magnitude of the impact of an action. These are very useful for the Ahwaz and Kirkby

project because they make clear the impacts.

3. Similarly the subjectively derived estimation of the importance of the impacts of the actions is recorded on a scale of 1-10.

4. The method communicates findings through a display matrix of impacts with accompanying text.

b. Weaknesses

The important weakness of the Leopold approach for hospital waste incinerators in Ahwaz and Kirkby or other project are its potential for widely varying quality of analysis; inadequate treatment of indirect effects; failure to separate project-related from non-project-related changes; and lack of consideration of system functional characteristics. Table 10.3.1 summarises and shows the strengths and limitation of the Leopold method which was used in an assessment of the EIA in the Kirkby project.

c. Opportunities

This method offers many opportunities for a hospital waste incinerator study such as wide flexibility in data and resource requirements like manpower, time, costs and technologies. Other opportunities of this method are that it also produces a practical pattern for the summarization and presentation of impacts. This is very important for cases such as the project in Iran where there are some limitations in manpower, time, costs and alternative technologies.

d. Threats

Although the Leopold matrix method identifies impacts and determines their magnitude and importance, it does not prescribe measurement strategies for them. For this reason it has a large dependence on subjective evaluations and so has a limited value for assessing social impacts such as shown by the studies in Iran and Kirkby. The subjective nature of the results is a threat to the decision making process.

e. Conclusion

In conclusion, with regard to strengths, weaknesses, opportunities and threats of the Leopold Matrix Method I preferred this method due to its ease of use and lack of need of professional specialists.

CHAPTER ELEVEN

CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

This thesis outlines and discusses the major environmentally significant impacts caused by hospital waste incinerators. This final chapter presents many conclusions and some recommendations. It is hoped that they will be useful for the EIA of future proposed hospital waste incinerators in Iran and elsewhere.

Hospital incinerators, as well as other methods of waste disposal, can introduce hazardous materials into a community's environment. For instance by: waste water; air emission; leaking storage containers; accidents; explosions and fires. The British Department of Health and Social Security believes that all contaminated waste from hospitals should be incinerated at the place of origin. (Department of the Environment, 1971). According to Lund (1977) incineration is the safest method for the disposal of hospital wastes but, since landfill costs are cheaper than incineration landfill must be considered as an alternative to incineration wherever possible. The disposal of hospital infectious and contaminated wastes by controlled landfill is, however, not recommended, unless the wastes are pre-sterilised by autoclaving before landfilling (Hnatko, 1975).

Even after the installation of pollution control equipment, fully checking the operation of hospital incinerators and implementing current regulations, hazardous materials have a chance of finding their way into the environment through gradual or unexpected emissions. When considering the range of hazardous materials disposed of in hospital incinerator processes, and their potential routes of discharge into the environment, there is one important question. "What is the risk of injury due to these materials?" After considerable study and a literature search, I found it is not an easy question to answer. I have, however, addressed it in chapters four and six. There is a old Chinese symbol which symbolises both chance and risk. It could easily refer to incineration of hospital waste. It is clear that no method of waste disposal is risk free, and incineration is no exception. This study shows the public concern about the effects of hospital waste incinerators (Chapters 7 and 8). There are many examples of incineration facilities in the United Kingdom which have failed and have been forced to close because of poor performance and public pressure; for example the incinerator in Preston. Therefore, the public image of incineration in Britain is not good. In the Kirkby area as in most of the other areas where municipal hazardous and hospital incinerators are planned, because they have worries about the potential risks, the local people are often opposed to them. In discussing risk in chapter four I stated that it was desirable to obtain agreement on the nature of risk in general and hospital incinerators in particular. From the literature, it is clear that often the available information which is necessary to assess the nature of the health risk from exposure to hospital waste is not adequate because of the limitations of the available methods of research. From the information that has been studied in this thesis, it appears that risks to health from hospital waste are probably small but very important (see chapter six). An efficient risk management programme relies upon a comprehensive understanding of the practical and real nature of the risks. To achieve this aim, it is necessary to understand the characteristic emissions of hospital incinerators and the risks that they pose to human health. As regards this problem, two things are very important. First, research and secondly, public access to and understanding of existing information. There is a need for more research in both Britain and Iran, because there is little epidemiological information relating to hospital waste incineration in the UK, and there is nothing at all available in Iran. The same situation appears to be true of most other countries.

In most locations the majority of people disagree over the siting of waste disposal facilities close to their homes but they may have different value systems, and perceive risks differently. Usually, educated people use statistics and their understanding of science to assess the risk of a hospital incinerator, but ordinary people base their assessment of risk on less logical methods such as hearsay, media reports and what appear to be largely emotional reactions.

For nearly four years I have been concerned with studying how Environmental Impact Assessment might be used in a positive way to mitigate the negative impacts of installing a hospital incinerator. There are, however, two diametrically opposed views on EIA. One is that, because it is fundamentally a good technique, it should be created as a statutory part of the normal planning procedure. The second is that EIA is counter productive to development projects, and may even prevent their implementation (see chapter five). I believe that EIA is the most important method of controlling pollution from hospital incinerators. Experience shows that EIA is basically a pollution control technique and helps us to a better understanding of the environment in all its aspects.

Some authors, for example Lee and Wood (1978) indicate that an EIA system might relate only to major projects such as:-

i. Large industrial complexes;

ii. Large transport infrastructure developments;

iii. Large mining and other extractive industry developments;

iv. Major new residential developments;

v. Other major infrastructure and non-industrial development projects.

I believe this list needs at least one item more. This would be for small projects such as the installation of a hospital waste incinerator for the disposal of toxic waste, where although the size of the project may be small, adverse public reaction, whether based on reality or imagination might be intense. Therefore, I believe and recommend that any small project which can create significant risk for the environment needs an EIA. The impact of all projects, large or small, clearly varies on some points such as: process; location; raw material used; and control of pollution. A hospital incinerator, although a small project, may produce hazardous materials and could have a greater environmental impact than that of some large plants. For instance a small project such as insecticide production could have hazardous impacts on the environment and human health. An Environmental Impact Statement for the installation of a hospital incinerator should contain enough technical data to permit planning authorities and citizen groups to make an assessment of the environmental impacts, and compare them with other techniques for the disposal of hospital waste. In practice, this means that an EIS for a hospital waste incinerator should present a detailed description of the following points:- the waste processes at the proposed incinerator; the nature of the waste to be destroyed; the transportation and store of waste; the planned control of air pollution; the impacts of emission from fly ash and bottom ash from stacks,the likely noise levels, the socio-economic impact, the public perception of the project, the potential for water pollution, the risk of accidents and the impact on flora and fauna. In other words such a study should be an orderly assessment of the overall impact of a planned hospital waste incinerator on the environment in terms of both physical and socio-economic impacts. A major and basic component of any impact statement must be a detailed description of the existing environment to provide a baseline from which changes can be measured or predicted. An EIA for the installation of a hospital waste incinerator must answer five questions:-

1. Why must the hospital waste incineration facility be constructed and what other options have been evaluated?
2. Why must the hospital waste incinerator facility be constructed at the particular site and what other sites were considered?
3. When must the hospital waste incinerator facility be constructed and what long term planning has been carried out to verify this decision?
4. What are the environmental impacts of construction and particularly operation upon the natural, social and economic environment?
5. How must the project be developed in order to ensure that the environment and humans are protected and to try to reduce all possible hazard impacts?

11.2 Recommendations

11.2.1 Recommendations for EIA implementation

The following section considers and recommends the environmental impact assessment process as it applies to proposed hospital waste incinerator activities. The main stages involved in carrying out an EIA for a hospital waste incinerator are as follows:

a. Screening

Screening, to decide whether an EIA is needed, is essential. It is, however, difficult to determine accurately what constitutes a significant project but some of the criteria used by Lee and Wood (1978) are useful (see page 383).

b. Scoping

Good scoping is essential. The effectiveness of an EIA depends to a large extent on scoping; that is, deciding on the factors which should be considered during the EIA. The important question is, what major forms of environmental impact should be considered? I believe an EIA procedure should take account of all or most impacts on the natural environment, on health and on the social structure and economic activity of the area. Scoping ensures that the EIA is concentrated on the most important impacts.

c. Choosing Methods

The final value of an EIA is depend on the validity. of the methods used for its organization. I have recommended the Leopold Matrix (Chapter 10) for this purpose because it identifies and explains the potential impacts of the proposed incineration. These include positive and negative direct and indirect impacts, short and long term impacts, and temporary, permanent and cumulative impacts. Also the interrelationships between human beings, flora, fauna, air, water and soil are demonstrated.

d. Establishing baseline data.

The value of an EIA is dependent on the quality of the baseline data. This data must therefore be both adequate and valid. The baseline data for both the proposed hospital waste incinerator and environment must be described in the environmental impact statement and include information on:- flora; fauna; soil; water; air; public perception and socio-economic impacts. The different emissions from fly ash and bottom ash must be described by type and quantity and the expected rate of production should be provided in the EIS.

A review of the relationship between the proposed hospital waste incinerator and existing environmental standards for the area likely to be affected, particularly including air quality and ambient noise standards, should be made. If necessary research should be initiated to collect essential information.

e. Assessing Impacts

Although the process is difficult, the magnitude and significance of the impacts arising from the hospital waste incinerator must be assessed in the EIS. Potential impacts of proposed incineration on the baseline environment should be identified and described. Both the positive and negative impacts of the incineration should be defined to cover both direct and indirect impacts, temporary, permanent and cumulative impacts, and short and long term impacts. The significance of identified impacts should be evaluated, taking into account relevant information.

f. Consideration of other sites and methods

The consideration of alternatives to the intended incinerator, and the suggestion of mitigating measures in the EIS must be given careful consideration. For each proposal all significant adverse impacts should be outlined, and all proposed mitigation measures should be identified and described, and evidence provided to show that these measures will be effective. If an alternative site or method of disposal is proposed, then the choice should be fully justified.

g. Publishing results

The EIA should result in a clear concise and easily understood Environmental Impact Statement. Any data, conclusions and quality standards derived from external sources should be completely acknowledged and referenced in the EIS. Data should be submitted without bias and receive appropriate emphasis. Finally, significant impacts should be reported in a non-technical summary.

h. Consultation and Public involvement

Provision should be made for the consultation and involvement of the public. It is important that sufficient numbers of at least the non-technical summary of the EIS are published to satisfy local demand.

i. Decision making

The result of steps a-h must then be taken into account by the planning authority in order to decide whether the project should proceed and whether or not changes should be made to the initial proposal. The planning should take into account national and regional considerations when reaching a decision.

j. Impact monitoring

If the proposal for an incinerator is implemented, it is essential that the impacts are monitored and any necessary action taken to ensure that breaches of planning consent are minimised.

11.2.2 Final Comments

In most countries there is no strategy for the disposal of hospital waste. Therefore, governments should establish or develop a national strategy for its disposal. In countries where there is a strategy, guidance is needed in order that the best available options are used to dispose of hospital waste safely, and minimise the risk to human health and the environment. Due to the critical environmental hazards arising from this type of waste (see chapter 9), it is necessary that those third world countries that lack suitable agencies, establish organizational bodies to enforce appropriate laws. Therefore I suggest that every country create an agency to oversee and control all aspects of hazardous waste including hospital waste management and its environmental health aspects.

Proper education is needed for those handling and transporting hospital waste, particularly for those managing hospital waste incinerator sites. Firstly they need to acquiring knowledge about handling and transporting hospital waste. Secondly they need to gain experience of the proper operation of incineration, as explained in chapter three.

Research is also needed into converting hospital solid waste to energy, to make the technique economically attractive, so that it would become the preferred method of waste disposal.

The author believes that incineration is normally the most effective way of disposing of hazardous hospital waste. Nevertheless, there is still much to learn about the health and environmental risks of the technique and he suggests that more research is needed to determine the long-term problems of air pollution and contamination of water and soil by emissions from hospital incinerators. We need more investigation into the potential health risks from the lead, nickel, dioxin, bacteria and viruses produced by hospital waste incineration.

REFERENCES

Ahmad, Y.J. and G.K. Sammy, 1985. Guidelines to Environmental Impact Assessment in Developing Countries. London: Hodder and Stoughton.

Airan, Damodar S.; Bell. A.M.; Asce, John H.; Airan, Lalita D.; McMurray, Daniel T.; 1980. Hospital solid waste management: A case study. Journal of the Environmental Engineering Division. August 1980. 106 (4) pp. 741- 755.

Albert, R.E., 1983. Comparative potency method for cancer risk assessment: Application to diesel particulate emissions. Risk Analysis, 3 (2) pp 322-325.

Allen, R.J.; Brenniman, G.R.; Darling, C.; 1986. Air pollution emissions from the incineration of hospital waste. Journal of the Air Pollution Control Association. 36 (7) pp. 829-831.

Allen Robert J.et al., 1989. Emission of air borne bacteria from a hospital incinerator. Journal of Air Pollution Control Association. 39 (2) pp. 164-168.

Amadio Vittorio and Mario Di Carlo, 1990. EIA for a special waste incineration in Rome. Valutazione Impatto Ambientale, Annoiv, 13 March 1990.

American Chemical Society, 1984. Chemical Risk: A Primer. Washington DC: American Chemical Society.

American Society of Mechanical Engineering. 1988. Hazardous Waste Incineration. A resource document. New York: American Chemical Society.

American Public Health Association, 1956. Hospital solid wastes and their handling. American Journal of Public Health, 46 (March) pp. 357-367.

Andrews, R.N.L., 1973. Approaches to Impact Assessment: Comparison and Critique. Paper presented to short course on Impact Assessment in Water Resource Planning, Ann Arbore, Michigan, 9 June.

Anon, 1979. What is solid waste made of ? American City and County, 94 (9) pp. 105- 107.

Anon, 1981, Britain's terrible heritage of toxic tips, New Scientist. pp. 408-410.

Anon, 1988. Integrated hazardous waste management facility opens near Swan Hills, Alberta. The Hazardous Waste Consultant. 6 (1) pp. 1-5.

Anon, 1991. The environmental protection Act 1990. Waste Management Today. No. 4 (1) pp. 26-34.

Ashby, Lord, 1982. Opening Address at A Seminar on Risk Cost and Pollution Held in Oxford 1982. Paper presented in Harwell Environmental Seminars Oxford 14-15 April 1982.

Atkins Ros, 1984. A Comparative Analysis of the Utility of EIA Methods. In: Perspectives on environmental impact assessment. Brain Clark, et al., Dordrecht: Reidel.

Baker, Dean B.; Greenland, Sander; Mendlein, James; Patricia, Harmon. 1988. A health study of two communities near the Stringfellow waste disposal site. Archives of Environmental Health. 43 (5) pp. 325-334.

Barbeito, M.S. and G.C. Gremillion, 1968. Microbiological safety evaluation of a industrial refuse incinerator. Applied Microbiology. 16 (2) pp. 221-295.

Barbeito M.S. and M. Shapiro, 1977. Microbiological safety evaluation of a solid and liquid pathological incinerator. Journal of Medical Primatol. 6: pp. 264-273.

Barstad J.A.B. 1978. Pesticides and Heavy Metals as food Contaminants In: Toxicological Aspects of Food Safety. Leonard B.J. (Ed) Barlin: Springer-verlag.

Barton, J. 1986. The Application of Mechanical Sorting Technology in Waste Reclamation-Options and Constraints. Stevenage: Warren Spring Laboratory.

Battelle Institute, 1978. The Selection of Projects for EIA: Commission of the European communities environment and consumer protection service. Brussels: C.E.C.

Baumgold, M.S. and G.A. Enk, (Eds) 1972. Toward a Systematic Approach to Environmental Impact Review. New York: Institute of Man and Science.

Baum, Bernard; Charles, H. Parker Debell and Richardson, 1973. Solid Waste Disposal. Vol. 1 Incineration and landfill. 1973. Michiguan: Ann Arbor Science Publishers.

Beanlands G. 1988. Scoping methods and baseline studies in EIA. In: Environmental Impact Assessment. Peter Watern (Ed). London: Allen and Unwin.

Bennett, Edward, 1989. Waste Management. December 1989. pp. 927-928.

Bisset, R., 1980. Methods for environmental impact analysis, recent trends and future prospects. Journal of Environmental Management. 11 (1) pp. 27-43.

Bisset, R., 1983. A Critical Survey of Methods for Environmental Impact Assessment. In: An annotated reader in Environmental Planning and Management. (Eds) O'Riordan, T. and R.K. Turner, pp. 168-186. Oxford: Pergaman.

Bisset, R. 1984. Post-development audits to investigate the accuracy of environmental impact predictions. Zeitschrift Fur Umweltpolitik. No.7 pp. 463-484.

Bisset, R. 1986. Introduction to impact assessment methods. Paper presented at the International Seminar on Environmental Impact Assessment, Aberdeen: University of Aberdeen. July 1986.

Bisset, R; - 1987. Methods for Environmental Assessment: a selective survey with case studies. In: Environmental impact assessment for developing countries. Asitk. Biswas and Qu Geping (Eds). London: Tycooly.

Bisset, R., 1989. Introduction to EIA Methods. paper presented at the International Seminar on EIA and Management. Aberdeen: University of Aberdeen. July 1989.

Bisset, Row, 1991. Introduction to EIA methods. Characteristics of impacts and use of matrices and networks. Personal communication.

Biswas, A.K. and Q. Geping (Eds) 1987. Environmental Impact Assessment for Developing Countries. London: Tycooly.

Block, S.S., and J.C. Netherton, 1977. Infectious Hospital Wastes: Their treatment and sanitary disposal. In Disinfection, sterilisation and preservation. SS. BlocK (Eds). Malvern, Pa: Lea and Febiyer. pp 723-739.

Bohne, H.B., 1970. Hydrochloric acid emissions from hospital refuse incinerators. Staub-Reinhalt Luft. 30 (8) pp. 27.

Booth, S. et al., 1965. Detection of Asthma epidemics. Archives of Environmental Health. 10: pp. 152-155.

Brenniman, Gary R. and Allen, Robert J., 1984 Disposal of infectious hospital waste; the problem in Illinois. Environmental Professional, 6 (3-4) pp. 247-248.

Bridgwater A. and K. Lidgren, 1981. Household Waste Management in Europe. Economics and techniques. London: Van Nostrand Reinhold.

British Medical Association, 1991. Hazardous Waste & Human Health. Oxford: Oxford University press.

Bromley, J. 1985. Agricultural, Industrial and Municipal Waste Management in Today's Environment. C96185. Imeche.

Brunner, C.R.; R.P. Brownell and J.R. Rowland, 1984. Pharmaceutical Plant Waste Disposal by Incineration. 1984 National Waste. pp: 451- 457. In: Processing Conference. Orlando, Florida.

Brunner, C.R. (1987). Biomedical Waste Incineration. Air pollution control association annual meeting 80 th annual meeting-papers vol: 80 Nos = 1-7.

Brunner, Calvin R.; Brown, Courtney H., 1988. Hospital waste disposal by incineration. Journal of the Air Pollution Control Association. 38 (10) pp. 1297-1311.

Bryant, C.J. R.W. Hartle, M.S. Crandall and Robert, P. 1989. Polychlorinated biphenyl, Polychlorinated Dibenzo-p-dioxin, and Polychlorinated dibenzofuran contamination in PCS disposal facilities. Chemosphere, 18 (1-6), pp. 569-576.

Burchell, R.W. and D. Listokin, 1975. The Environmental Impact Handbook. New Brunswick: Center for Urban Policy Research, Rutgers University.

Burlace C. J. 1983. Waste-derived fuel: The Production and Testing of Refuse-Derived Fuels from Municipal Waste. In: Disposal and recovery of Municipal solid waste. Michael E. Henstock (Ed). London: Butter Norths.

Burke, B., 1984. Some ABCs in addressing risk. EPA Journal, pp. 12-13.

Campbell, Dave. 1989. Management of Hospital Wastes in Canada. Paper presented at the Canadian waste management Conference, Edmonton, October 7-9 1989.

Canadian Standards Association, 1988. Handling of Waste Materials within Health Care Facilities. A national standard of Canada. Pointe-Claire. Ontario: Canadian Standards Association.

Canter L.W. 1977. Environmental Impact Assessment. London: McGraw Hill.

Canter, L. 1986. Methods for Impact Assessment. Paper presented at the International Seminar on Environmental Impact Assessment, July 1986, University of Aberdeen.

Catlow, J. and Thirlwell C. G., 1977. Environmental Impact Analysis Research Report 11, London: Department of the Environment.

C.E.S. Limited. 1982. Knowsley Metropolitan Borough Council Merseyside Metropolitan Council; Kirkby: An outer Estate. C.E.S. paper.

Census, 1971. Information supplied by Information Centre, Kirkby. Personal communication.

Census, 1981. Information supplied by Information Centre, Kirkby. Personal communication.

Chang Sen-dou, 1978. Chinese perception and transformation of arid lands, Chinese Geographer 10 (Spring) pp. 1-12.

Chapman K., 1981. Issues in EIA. Progress in Human Geography. 5 (2) pp. 190-210.

Chermisinoff, Paul N., 1989. High hazard pollutants: Asbestos, PCBs, dioxins, biomedical wastes. Pollution Engineering. 21 (2) pp. 58-65.

Chiou, C.T.; Peters, L.F.; Freed, V.H. 1979. A physical concept of soil- water equilibria for non ionic organic compounds. Science No. 206. pp. 831-832.

Clark Brian D. et al., 1976. Assessment of Industrial Applications. A manual. Department of the environment research report 13. London: Department of the environment.

Clark B. D.; K. Chapman; R. Bisset and P. Wathern, 1978. Methods of Environmental Impact Analysis. Built Environmental. 4 (2) pp. 119-121.

Clark, B.; Chapman, K., Bisset, R.; and Wathern P. 1979. Environmental Impact Analysis. In: pp. 51-81. Land use and landscape planning. Lovejoy D.; (Ed). Glasgow: L. Hill.

Clark, Brian D.; Bisset, R. and Wathern P. 1980. Environmental Impact Assessment; a bibliography with abstracts. London: Mansell.

Clark, B.D.; Chapman, K.; Bisset, R.; Wathern, P.; and Barret,M. 1981. A Manual for the Assessment of Major Development Proposals. London: HMSO.

Clark Brian D.; Alexander Gilad; Ronald Bisset and Paul Tomlinson, Eds., 1984. Perspectives on Environmental Impact Assessment. Dordercht: Reidel.

Clark, A.J., 1979. Emission of Sulphur Dioxide, Nitrogen Oxides, and Particulate Matter from Coal-Burning Power Stations. In: Environmental effects of utilising more coal. (Ed) F.A. Robinson. London: Chemical Society.

Clark C.S. et al., 1982. An environmental health survey of drinking water contamination by leachate from pesticide waste dump in Hardeman County. Tennessee. Archives of Environmental Health. 37. pp. 9-18.

Clayton P. and Scott, D.W. 1986 a. The Measurement of Suspended Particle Heavy Metal and Selected Organic Emissions at Gateshead Municipal Refuse Incinerator. LR 569 . Stevenge: Warren Spring Laboratory.

Clyton P. and Scott, D.W. 1986 b. The Measurement of Suspended, Particle Heavy Metal and Selected Organic Emissions at Sheffield Municipal Refuse Incinerator. LR 570. Stevenage: Warren Spring Laboratory.

Clayton, P. and Scott, D. W., 1986 c. The Measurement of Suspended Particle, Heavy Metal and Selected Organic Emissions at Wolverhampton Municipal Refuse Incinerator LR571 . Stevenage: Warren Spring Laboratory.

Cohen, H. 1983. Orientation of the Future Extension and Application of Knowledge in the Field of Environmental Health. WHO/EURO ICP/PPE (2)/8. Working Group on health and environment 12-16 December, Vienna. Geneva: World Health Organization.

Commission of the European Communities, 1982. Environment and quality of life. Survey of the Collection, Recycling and Safe Disposal of Hospital Wastes in the Member States of the European Communities. Final report. EUR 7877 EN. Luxembourg: CEC.

Commission of the European Communities, 1985. (CEC). Council Directive of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment. Official Journal of the European Communities, L 175 5th July, 1985 pp. 40-48.

Commission of the European Communities, 1992. Directorate- General Xl Environmental, Nuclear safety and civil protection. European Community Environment Legislation. Vol 6: Waste Luxembourg: CEC.

Commoner B.; Webster, T.; and Shapiro, K. 1985. Environmental Levels and Health Effects of PCDDs and PCDFs. Centre for the Biology of Natural Systems, Flushing, New York: Queens College.

Connett, Paul and Webster, Tom, 1987. " An estimation of the relative human exposure to 2,3,7,8-TCDD emissions VIA inhalation and ingestion of Cow's milk. Chemosphere, 16 (819) pp. 2079-2084.

Corwin, R., Heffernan, P.H., Johnston, R.A., Remy, M., Roberts, J.A., and D.B. Tyler. (Eds) 1975. Environmental Impact Assessment. San Francisco: Freeman, Cooper and Co.

Council on environmental quality, 1980. Environmental Quality-the Eleventh Annual Report of the Council on Environmental Quality. Washington DC: Council on environmental quality.

Covello, V.T. 1983. The perception of technological risks; a literature review. Technological Forecasting and Social Change. No. 23 pp. 285-297.

Covello, V.T. & J. Mumpower, 1985. Risk analysis ana risk management an historical perspective. Risk Analysis, No. 5 pp. 103-120.

Cross, Jr. Frank, L. Jr and George Noble. 1973. Handbook on Hospital Solid Waste Management. Lancaster. Pa.: Technomic.

Cross and H.E. Hesketh, 1985. Controlled Air Incineration.Lancaster. Pennsylvania: Technomic.

Cross, Frank L. Jr., P.E. and Rosemary Robinson, 1989. Infectious waste, pp. 4.35-4.46 In: Standard Handbook of Hazardous waste Treatment and Disposal. Freeman. Harry (Ed). London: McGraw Hill.

Cross, Frank L.; Hesketh, Howarde.; Rykowski, P.Kay. 1990. Infectious Waste Management. Lancaster. Pa. Technomic.

Curtis C. Travis; S. Chrystal Cook, 1987. Hazardous Waste Incineration and Human Health; Health and Safety Manuscript in Publication Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Cundari, K.L., and Lauria,J. M., 1986. Ashfills and leachate. Waste Age. November pp. 82-88.

Dean, F.E. and Graham G., 1978. The Application of Environmental Impact Analysis in the British Gas Industry. Paper presented at the UNECE Symposium on the Gas Industry and the environment, Minsk.

Dee, N. et al., 1972. Environmental Evaluation System for Water Resource Planning. Columbus, Ohio: Battelle Columbus Laboratory.

Dee, N. et al., 1973. Environmental Evaluation System for Water Resources Research. No. 9, pp. 523-535. IL: Fahringer DC.

Department of the environment, 1971. Refuse disposal. London: HMSO.

Department of Health and Human Services, 1978. Centres for Disease Control. Isolation Techniques for Use in Hospitals. Atlanta, Georgia: CDC.

Department of the Environment, 1983. Waste Management paper No: 25 Clinical Wastes. London: HMSO.

Department of the Environment. 1989. Dioxins in the Environment. A report of an Interdepartmental working group on polychlorinated dibenzo- paro-dioxins and polychlorinated dibenzofurans. pollution paper No.27. London: HMSO.

Depue, R.A., and Monroe, S.M. 1986. Conceptualization and measurement of human disorder in life stress research: The Problem of Chronic Disturbance, and Social Psychology. No. 28, pp. 225-35.

Diamant. R.M.E., 1974. The Prevention of Pollution. Refuse Incineration. London: Pitman.

Dillman, D. 1978. A Mail and Telephone Surveys. New York: John Willey and sons.

Ditton, R.B. and Goodle, T. I. 1972. Environmental Impact Analysis: Philosophy and Methods. Madison: University of Wisconsin press.

Dobry G. 1975. Review of the Development Control System. Final report. Department of the Environment. London: HMSO.

Dohrenwend, B.P., and Dohrenwend, B.S. 1981. Socioenvironmental factors, stress and psychopathology-part 1: Quasi-experimental evidence on the social causation-social selection issue posed by class differences. American Journal of Community Psychology No.9 (2): pp. 129-146.

Donaldson, R.J. 1984. Medical Effects of Atmospheric Pollution and Noise. In: Perspectives on environmental impact assessment. Clark, B; Gilad, R.; Bisset and Tomlinson (Eds). pp 105-119. Dordrecht: Reidel.

Dorland's Illustrated Medical Dictionary. 1974. p 1748. Philadelphia, W.B. Saunders Company.

Doyle, B.W.; Drum, D.A.; Lauber, J.D. 1985. The smouldering question of hospital wastes. Pollution Engineering. 17 (7) pp. 35-39.

Eastwood D.A. and W.G. Cart, 1981. The Irish Dune Consumer, Journal of Leisure Research No. 13: pp. 273-281.

ECE Group LTD. 1984 Energy from Waste Plant Victoria Hospital Group. London Ontario. paper presented by the ECE Group LTD. Don Mills Ontario to the Task Force on energy management in health care facilities in Canada. October 2. 1984.

Edwards, J.B. 1977. Combustion: the Formation and Emission of Trace Species. Ann Arbor, Michigan: Ann Arbor Science.

Edward, J. Martin; Joseph T. Swartzbaugh; Alexander Mathews, 1985. Particle limitation of Waste Characteristics for Effective Incineration. Washington DC: EPA.

Environmental Protection Agency. 1970. Pathogens Associated with Solid Waste Processing. Washington DC: EPA.

Environmental Protection Agency, 1980. Hazardous Waste Facility Siting: A critical problem, SW-865. Washington DC: EPA.

Environmental Protection Agency, 1981. Engineering Handbook for Hazardous Waste Incineration. report No. SW-889. Washington DC: EPA.

Environmental Resources Ltd. 1984. Prediction in Environmental Impact Assessment. Publication No. 17, Ministry of Housing, physical planning and environment and agriculture fisheries.

Environmental Protection Agency, 1986. Guide for Infectious Waste Management EPA/530-SW-104, Washington, DC: EPA.

Environmental Protection Agency. 1987. Office of solid waste and emergency response. Municipal Waste Combustion Study: Report to congress. Washington DC: EPA.

Environmental Protection Agency. 1988 a. Statement of Lee, M. Thomas, Administer of the USEPA, Before the Subcommittee on Transportation, Tourism and Hazardous Materials of the Committee on Energy and Commerce. US. House of representatives. Washington DC: EPA.

Environmental Protection Agency , August 1988 b. Hospital Waste Study-Data Gathering Phase, final report. Washington DC: EPA.

Environmental Protection Agency, 1988c. Hazardous Waste Incineration, a resource document. Washington DC: EPA.

Environmental Technology Consultants Limited, 1989. An Environmental Impact Assessment on Behalf of Waste Management limited a Hospital Waste Incinerator at Hammond Road Kirkby Industrial Estate, Knowsley Mersyside.

Environment Canada, 1974. An Environmental Assessment of Nanaimo Port Alternatives. Ottawa: Environment Canada.

Environment Ontario, 1986. Incinerator Design and Operating Criteria. Vol.II. Biomedical Waste Incinerators. Ontario: Ministry of the Environment.

Environmental Committee on Toxic Waste. 1989. House of Commons, 2nd report, London: HMSO.

Erickson Paul A. 1979. Environmental Impact Assessment Principles and Applications. London: Academic Press.

Erickson, M.D.; Swanson, S.E. Flora J.D. and Hinshow, G.D. 1989. Polychlorinated Dibenzofurans and Other Thermal Combustion Products from Dielectric Fluids Containing Polychlorinated Biphenyls. Environmental Science and Technology. 23(4) pp. 462-470.

Farber, E., 1980. Sequential analysis of liver cancer indication. Biochimica et Biophysica. Acta No. 605: pp. 149-166.

Firgerio, A. 1978. The Seveso case: TCDD in animals from contaminated areas. Methodological Surveys in Biochemistry. No. 7 : pp. 161-166.

Fischhoff, B., Slovic, P., Lichtenstein, S., Combs, B., 1978. How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Sciences. No. 9 , pp. 127-152.

Fischhoff, B.; Slovic, P.; and Lichtenstein, S. 1979. Weighing the risks. Environment. No. 21 (4) pp. 17-20, 32-38.

Fischhoff, Baruch; Sarah, Lichtenstein; Paul, Slovic; Stephen, L. Derby; and Ralphl, Keeney, 1984. Acceptable Risk. Cambridge university Press.

Fishbein, Martin, and Ajzen, Icek. 1975. Belief, Attitude, Intention and Behaviour: An Introduction to Theory and Research. Reading, Pa: Addison Wesley.

Fletcher, A.C., 1985. Reproductive Hazards of Work. London: Association of Scientific, Technical and Managerial Staffs.

Forester William S.; John H. Skinner. (Eds) 1987. International Perspectives on Hazardous Waste Management. London: Academic Press.

Franklin Associates, Ltd., 1986. Characteristics of Municipal Solid Waste in the United States, 1960 to 2000. Wahington DC: Environmental Protection Agency, Office of Solid Waste.

Freeman, Harry M. (Ed.) 1989. Standard handbook of hazardous waste treatment and disposal. New York: McGrow Hill.

French. H.F. 1990. You Are What You Breath World Watch. 3 (3) pp. 27- 34.

Garner J.F. 1979. Environmental Impact Statements in US. and UK. Journal of Planning and Environmental Law. March, pp. 143-145.

Garner, Julia S., and Maritn S. Favero, 1985. Guideline for Hand Washing and Hospital Environmental Control. Hand washing and hospital environmental control. pp. 15-16.

Garvin, M., 1988. Facilities management, definition of infectious waste broadened. Hospitals. part 1, Jan 1988. pp97-98.

Gatrell, A.C., 1990. On Modelling Spatial Point Patterns Epidemiology: Cancer of the larynx in Lancashire, Research report No.9. North West Regional Research Laboratory,

Gatrell and Andrew A. Lovett, 1992. Burning Questions Incineration of Wastes and Implications for Human health. In: Waste location, spatial aspects of waste management, hazards and disposal. Michael Clark, Denis Smith and Andrew Blowers (Eds), pp. 143-157, London: Routledge.

Gilbertson, Wesley E. 1969. Present and Future Trends in Municipal Disposal of Solid Wastes. In: Problems in community wastes management, Geneva W.H.O.

Gilde, L.C. 1971. Pollution Control in Food Industries. In industrial pollution control handbook. Ed. by Herbert F. Lund. London: McGrow-hill.

Giroult, E., 1990. WHO interest in Environmental Health Impact Assessment. In: Environmental Impact Assessment. Theory and practice. Peter Wathern (ed.) 1990, London: Routldge.

Glaser, Z.R., 1977. Special Occupational Hazard Review with Control Recommendations for the Use of Ethylene Oxide as a Sterilant in Medical Facilities.New York: US. Department of Health, Education and Welfare.

Go, Frank C.,1987. Environmental Impact Assessment. An Analysis of Methodological and Substantive Issues Affecting Human Health Considerations. London: Monitoring and Assessment Research Centre King's College.

Gordon, J.G.; Zark.N.; Brooks; K.; Cofone N.; Ruban, H.; Canelles, G.; Goldgraben, R.; ciffi,J.; 1979. Disposal of Hospital Wastes Containing Pathogenic Organisms. final report, U.S. Army Medical research and development command; contract No September 1979; p 296.

Gordon, J.G, et al., 1980. Disposal of Hospital Wastes Containing Pathogenic Organisms. McLean. Va: Mitre Corporation.

Gow. J.S. 1988. Risk Assessment of Chemicals in the Environment. Mervyn L. Richardson (Ed), London: Royal Society of Chemistry. 1988.

Grant Alex, 1971. Tales of Old Kirkby. Unpublished.

Gratt, L.B. 1987. Uncertainty in risk assessment, risk management and decision making. In: Advances in Risk Analysis . V.T. Novello, et al., (Eds). New York: Pleneum Press.

Graybill, D.L. 1985. If environmental Impact Assessment is everything, maybe it is nothing-some arguments for more attention to practical aspects of implementation. Environmental Professional. No.7: pp 344-351.

Graydon, A.G., 1979. Flames Their Structure, Radiation and Temperature. London: Chapman and Hall.

Greater Manchester Hazards Centre, 1989. Discussion Paper on Waste Disposal. Manchester: GMHC.

Green, C.H. and Brown, R.A., 1977. Hazards.(letter), New Scientist. 74 (1056) pp. 667-668.

Green, C.H. and Brown, R.A., 1978. Counting lives. Journal of Occupational Accidents No. 2, p 55-70.

Green, S.E., Longhurst, J.W.S. & Lee, D.S., March 1988. Primary Teaching Pack Acid Rain. Manchester: Manchester Polytechnic.

Greenberg, M.R. and R.F. Anderson, 1984. Hazardous Waste Sites. The credibility gap, Centre for Urban Policy Research, New Jersey: University of New Jersey.

Grisham J.W., (Ed.) 1986. Health Aspects of the Disposal of Waste Chemicals. New York: pergamon press.

Gunderson, E.K.E., and Rahe, R.H. (Eds). 1974 Life Stress and Illness. Springfield: Thomas.

Hackman, E., 1978. Toxic organic chemicals destruction and waste treatment. Pollution Technology Review No.40. New Jersy: Noyes data corp.

Haigh, N., 1987. Environmental Assessment: The E.C. Directive. Journal of Planning and Environment Law. Janvary. pp. 4-20.

Hall, Stephen K. 1989. Infectious waste management a multi-face problem. Pollution Engineering. 21 (8), pp 74-78.

Halliwell, P.R. (ed). 1972. Incineration of Refuse and Sludge. In: Proceeding of a Symposium Held by the Department of Civil Engineering. Southampton: University of Southampton. January, 1972.

Hammer. R. 1980. The Resource Conservation and Recovery Act.Paper presented in: Third Conference on advanced pollution control for the metal finishing Industry. Cincinnati, Ohio, February, 1980.

Hancock, T., 1991. EIA: Motor racing for TAG/McLaren. Integrated Environmental Management. No.3: pp. 14-17.

Handmer, John and Edmund Penning-Rowsell, (eds). 1990. Hazards and the Communication of Risk. Aldeshor: Gower.

Hangebrauch, R.P., 1964. Emissions of polynuclear Hydrocarbons and other pollutants from heat generation and incineration processes, Journal of the Air Pollution Control Association. 14 (7).

Harashina, S., 1988. Environmental dispute resolution in road construction projects in Japan. Environmental Impact Assessment Review. No. 8: pp. 29-41.

Harthill, Michalann. 1984. Hazardous Waste Management :In whose backyard? (Ed) Michalann Harthill. Epping: Bowker.

Hay D., Stewart, 1984. A Canadian Federal Perspective. In: Hazardous Waste Management. in whose backyard? Ed. by Michalann Harthill. Epping: Bowker.

Hazardous Waste Inspectorate, (HWI) 1985. Hazardous Waste Management: an overview first report of the Hazardous Waste Inspectorate London: Department of the Environment.

Health Services Advisory Committee, 1982. Health and safety commission. The Safe Disposal of Clinical Waste. London: Her Majesty's Stationery Office (HMSO).

Healthy Knowsley by the year 2000. July 1991. Knowsley Metropolitan Borough and St. Helens and Knowsley Health Authorities.

Heer, J.E. and D. J. Hagerty. 1977. Environmental Assessments and Statements. New York: Van Nostrand Reinhold.

Her Majesty's Stationery Office, 1989. Environmental Assessment; A Guide to Procedures, DoE/Welsh Office. London: HMSO.

Hershkowitz, Allen, 1990. Without a trace, Handling medical waste safely. Technology Review. 93 (6) 35-37, 39-40.

Hitchcock, D., 1979. Solid waste disposal: Incineration. Chemical Engineering 21 (May), pp. 185.

Hjelmar, O. 1982. Leachate from Incinerator Ash Disposal Sites. Paper presented at international workshop on municipal waste incineration, Montreal, Canada, October, 1982.

HMSO. Collection and Disposal of Waste Regulation, 1988. SI. 1988/No. 819. London: HMSO.

Hnatko, S. 1975. Disposal of Infectious Wastes. Dimensions in health services. December 1975. pp. 42-43

Hobbs, Betty C. and Diane Roberts, 1987. Food Poisoning and Food Hygiene. London. Edward arnold.

Holmes, J.R. 1981. Refuse Recycling and Recovery. London: John Wiley and Sons.

Holmes John R. 1983. Waste Management: The option facing the Public Authorities. In: Disposal and Recovery of Municipal Solid Waste (ed), Michael E. Henstock. London: Butterworths.

Houston, D.B., 1960. Risk theory. Journal of Risk and Insurance. No. 27: pp. 77-82.

Howe, Holly L., 1988. A comparison of actual and perceived residential proximity to toxic waste sites. Archives of Environmental Health November/December 1988, 43 (6) pp. 415-419.

Iglar, A.F., Bond, R.G. 1973 Hospital Solid Waste Disposal in Community Facilities. EPA 670 048, PB 222 018, 349. Washington DC. Environmental, Protection Agency.

Incinerator Institute of America, 1955. Selection of Incinerators for Hospital Use. Bulletin Hospital. New York: Incineration Institute of America.

Incinerator Institute of America (I.I.A) November 1968 Incinerator Standards. New York: Incineration Institute of America.

Information Center, Kirkby, 1990. Personal communication.

Institute for environmental studies, 1977. Documentation of Environmental Change Related to the Columbia Electric Generating Station. IES. report 82. Madison, Wis: Institute of Environmental Studies, University of Wisconsin.

Interdepartmental working group on Risk-Benefit analysis, 1989. Risk-Benefit Analysis in the Management of Toxic Chemicals. Ottawa: Agriculture Canada.

Jackson Edgrl, 1981. Response to earthquake hazard: The west coast of North America. In: Environment and Behaviour No. 13 (July 1981): pp. 387-416.

Jafari Mosavi, S.A.A. 1991. The Impact of a Proposed Incinerator Installation on the Health of a Community. Salford: Environmental Resources Unit, University of Salford. Unpublished.

Jager, Eva; Lutz, Xander; Henning, Ruden, 1989 Medical Waste Microbiologic Studies of Wastes of Various Specialities at a Large and small Hospital in Comparison to Household Refuse. Zentralatt fur hygiene undr unwel tmdizin. 188 (3+4) pp.343-364.

Johns Hopkins Hospital, 1979. Policies and Procedures for the Control of Infectious: Waste Cytopathology. Baltimore, Maryland: the Johns Hopkins Hospitals.

Johns Hopkins University School of Hygiene and Public Health, Hazardous Waste Site Study Group. 1981. Final report: Design of Environmental Health Effects Studies Stemming from the Potential for Human Exposure to Toxic Waste in Memphis, Tennessee. Memphis: Tennessee Department of Public Health.

Johnson, R.& Luken R.A., 1987. Radon risk information and voluntary protection: evidence from a natural experiment. Risk Analysis. No. 7, pp.97-107.

Jumpei Ando, 1989. Recent Developments in Pollution Control Technology for Boilers, Furnaces and Incinerators. In: The management of hazardous substances in the environment. (Eds). K.L. Zirm and J.Mayer, London: Elsevier.

Kahnman, D.; P. Slovic; A. Tversky; 1982. Judgment Under Uncertainty: Heuristics and Biases. Cambridge: Cambridge University Press.

Kates, R.W, 1978. Risk Assessment of Environmental Hazard, New York: John Wiley.

Kates. Robert W. and Jeanne X. Kasperson 1983. Comparative Risk Analysis of Technological Hazards (A Review) Proceedings of the National Academy of Sciences USA.

Kelly, N, R. Allen, G. Brenniman, J. kusek, 1983.Environment of Bacterial Emissions from a Hospital Incinerator. VIth World Congress on Air quality, volume 2. 227-232.

Kellermeyer, D.A., S.E. Ziemer and S.L. Stewart, 1987. Health Risk Assessment for the Pinellas County Resource Recovery Facility. USA, Florida.

Kellermeyer, D.A., S.E. Ziemer, 1989. Public health risks associated with disposal of MSW incineration ash. Paper presented at International Conference on Municipal Waste Combustion Hollywood, Florida, April, 1989.

Kenaga, E.E.; Goring, C.A.I. 1980. Relationship Between Water Solubility, Soil Sorption, Octanol Water Partitioning, and Concentration of Chemicals in Biota. In: Aquatic toxicology: Special technical publication 707. Eaton, J.G.; Parish, P.R; Hendricks, A.C.; (Eds) pp. 78-115. Philadeiphia: American Society for testing and materials.

Kent, D.c.; W.A., Petty John and T.A., prickett. 1985. Analytical methods for the prediction of leachate plume migration. Groundwater Monitoring Review. 5 (2): pp. 46-59.

Kharbanda, O.P.; E.A., Stallworthy, 1990. Waste Management, Towards a Sustainable Society. Aldershot: Gower.

Kiang, Y.H. 1980. Incineration of Hazardous Organic Wastes.In: Resource Recovery today and tomorrow. 9th National Waste Processing Conference, Washington DC. May 1980. pp. 93-102.

Kremer, Jayg; Franklin D. Dryden; Steven J. Hyland, 1975. Disposal of Hospital Infectious Solid Wastes to Sewerage System. 30 th industrial waste conference, Purdue University Indiana. May 1975.

Krewski D., and B. Somers, 1987. Risk Perception in a decision making context. Journal of Environmental Science and Health. 5 (2)

Kurland, L.T.; S.N., Faro; H., Siedier, 1960. Minamata disease; the out break of a necrologic disorder in Minamata, Japan, and its relationship to the ingestion of seafood contaminated by mercuric compounds. World Neurology, 1: pp. 370- 395.

Lauber, J.D. 1987. New perspectives on toxic emissions from hospital incinerators. New York: New York State Legislative Commission on Solid Waste Management and Materials Policy.

Lave, L.B. and E.P., Seskin.,1977. Air Pollution and Human Health. Baltimore: John Hopkins University Press.

Lee, N. and C., Wood, 1978. Environmental Impact Assessment of projects in EEC. Countries Journal of Environmental Management. 6, pp. 57-71.

Lee, N., and C., Wood, 1980 a. Environmental Impact Assessment in the European Economic Community. EIA. Review. 1 (3) pp. 287- 300.

Lee, N. and; C. Wood, 1980 b. Environmental Impact Assessment for Use in Project Appraisal and Physical Planning. Occasional paper No. 7. Manchester: Department of Town and Country Planning University of Manchester.

Lee, N. and C. Wood, C. 1980 c. E.Y.A. Procedures Economic Community. Paper presented for a Conference in Essex University.

Lee, N., 1983. Environmental Impact Assessment: A Review Applied Geography. No.3 pp. 5-27.

Lee, N. and C. Wood, 1983. The effects of population and·industrial change and environmental quality in major conurbations. Journal of Environmental Management. No. 16, pp. 91-107.

Lee, C.C.; George L., Huffman; and Donald A. Oberacker, 1986. An "Overview of hazardous/ toxic waste incineration. Journal of the Air Pollution Control Association. 36 (8).

Lee C.C. 1988. A model Analysis of metal partitioning, in a hazardous waste incineration system. Journal of the Air Pollution Control Association. 38 (7) pp. 941-945.

Lennette E.H.; A. Below; W.J. Hauser; N.Y. Shadomy 1985. Manual of Clinical Microbiology 4thed American Society for Microbiology. Washington DC: American Society for Microbiology.

Leopold, L. B.; Clarke, F. E.; Hanshaw, B.B.; and Balsley, J.R. 1971. A Procedure for Evaluating Environmental Impact. US. Geological survey circular. 645. Washington DC: US Geological Survey.

Leshan, L.L., 1959. Psychological states as factors in the development of malignant disease: A critical review. Journal of the National Cancer Institute, No. 22, pp. 1-18.

Levi, L. (Ed), 1971. Psychosocial Environment and Psychosomatic Diseases. Vol.1. New York: Oxford University press.

Lewise, B. and G. Elbe, 1961. Combustion, Flames and Explosions of Gases. London: Academic press.

Lewtas. J. et al., 1987. Identification and Comparative Risk Assessment of Airborne Carcinogens from Combustion Sources, draft report, EPA. Health Effects Research Laboratory, Genetic Bioassay Branch, research Triangle park, NC: Environmental Protection Agency.

Liao, P.B. 1974. Fluidized- bed sludge incinerator design". Journal of the Water Pollution Control Federation. 48 (8) pp. 1899-1913.

Lloyd et al., 1988. Twinning in Human Populations and in Cattle Exposed to Air Pollution from Incinerators. British Journal Industrial Medicine. V:45 pp. 556-560.

Lohani, B.N. and N. Halim, 1987. Recommended Methodologies for rapid environmental impact assessment in developing countries: Experiences derived from case studies in Thailand. In: Environmental Impact Assessment for Developing Countries. (Eds) Asit K. Biswas and Qu Geping. London. Tycooly.

Lowrance, William W. 1981. Environmental Protection for Health Promotion. Washington. DC: George Washington University Press.

Lund, M.A. 1977. Harwell laboratory: Survey of Hospital Wastes in the Oxford Area Volume I and II. Harwell: Harwell Labratory.

Malhotra, S.P., 1979. Traditional perceptabilities of environment and desertification: A case study, "Economic Geography" No. 53 (October) pp. 347-352.

Maltezou, Sonia P.; Asit K. Biswas and Hans Sutter, 1987. Hazardous Waste Management. Selected papers from an international expert workshop convened by UNIDO in Vienna, 22-26 June 1987.

Marrack, David. 1988. Hospital Red Bag waste. Journal of the Air Pollution Control Association. 38 (10) pp. 1309-13011.

Martin, William F.; John M. Lippitt and Timothy G., Brothero, 1987. Hazardous Waste Handbook for Health and Safery. London: Butterworths.

Matthews, P.J. 1987. Legal and scientific constraints. In stitution of Civil Engineers Conference on marine treatment of sewage and sludge 1988.

McCabe, L. C.; and G. D. Clayton, 1952. Air pollution by hydrogen sulphide in Poza Rica, Mexico. Hygiene and Occupation Medicine. No. 6 pp. 199.

McCarroll, J.; and Bradley. 1966. Excess mortality as an indicator of health effects of air pollution. American Journal Public health. No. 56. pp. 1933.

McCrae M. Allan, March, 1980. Solid Waste Incineration and Heat Recovery at the Royal Jubilee Hospital in Victoria, B.C. Prepared for Fisheries and Environment Canada Environmental protection Pacific Region. Canada.

McHarg, I. 1968. A Comprehensive Highway Route-Selection Method Highway Research Record No. 146. pp. 1-15 Washington DC: Highway Research Board.

Merseyside Police, 1978. Reported: Kirkby New town. Volume I, II. Unpublished.

Mileti, S. Denniss; Thomas E. Drabek; and J. Eugene Haas, 1975. Human systems Extreme Environment: A sociological perspective, program on technology environment and Man monograph No.21 Boulder: University of Colorado, Institute of Behavioral Science.

Miller, C. and Wood C. 1983, Planning and Pollution. An examination of the role of land use planning in the protection of environmental quality, Oxford: Clarendon Press.

Ministry of Health and Environmental Protection (MHEP), 1980. Governmental Standpoint on Environmental Impact Assessment.Leidschendam.

Ministry of Information and Tourism, 1974. Basic facts about Iran. Teheran: Ministry of Information and Tourism publications department.

Miosh, Malcolm Dewisllb, 1991. Tolley's Health and Safety at Work Handbook. Fourth edition. Croydon: Tolley.

Mitchell, James K. 1984. Hazard Perception Studies: Convergent concerns and divergent approaches during the past decade. In: Environmental Perception and Behaviour. Thomas F. Saarinen, David Seamon and James L. Sell. (Eds). Chicago. IL: University of Chicago Department of Geography.

Moore, Thomas, M.A. 1972. Historic Society of Lancashire and Cheshire Transaction 1853-1854. Some notes, historical and ecclesiastical, on the chapelry of Kirkby, Walton-on-the-Hill, Lancashire. Unpublished.

Munn, R.E. Ed. 1975. Environmental Impact Assessment. Principles and procedures, Scope report 5. Toronto: International Council of Scientific Unions Scientific Committee on Problems of the Environment.

Munn, R.E. 1979. Environmental Impact Assessment. Chichester: John Willey & sons.

Murnyak, G.R.and D.C. Guzenich, 1982. Chlorine emission from a medical waste incinerator Journal of Environmental Health. Sept /Oct.

National Analysts, Inc. 1973. Metropolitan Housewives, Attitudes Toward Solid Waste Disposal. Washington DC: Environmental Protection Agency

National Research council. 1983. Risk Assessment in the Federal Government: Managing the Process. Washington DC: National Academy Press.

National Society for Clean Air and Environmental Protection (NSCA). 1990. Pollution Handbook.

National Society for Clean Air and Environmental Protection (NSCA), 1991. Pollution Handbook. Brighton: Nsca.

Nehnevajsa, J., 1984. Low probability/ high - consequence risks. In: Issues in credibility and acceptance. Raya Wailer and Vincent T. Covell (Eds). pp. 521-529.

Neutra R. 1983. Roles for epidemiology: The impact of environmental chemicals. Environmental Health Perspectives. 48 pp. 99-104.

Nisbeltt, R. and Ross, L., 1980. Human Inference: Strategies and Shortcomings of Social Judgment. Englewood Cliff, NJ: Prentice Hall.

Nygren, M.; C. Rappe; G. Lindstrom; M. Hansson; P Bergqvist and S. Marklund; 1987. Identification of 2,3,7,8-substituted Poly-Chlorinated Dioxins (PCDDs) and Dibenzofurans (PCDFs) in Environmental and human samples. In: Chlorinated Dioxins and Dibenzofurans in the Total Environment, V: 3, London: Butterworth.

Okrent, D. 1980. Comment on societal risk. Science. No. 208: p. 372-375.

Openshaw, S., M. Charlton; C. Wymer and A. Craft, 1987. Amark I Geographical analysis machine for the automated analysis of point data sets. International Journal of Geographical Information Systems. 1 (4) pp. 335-358.

Oppelt, E.T., 1987. Incineration of hazardous waste: A critical Review. Journal of the Air Pollution Control Association. 37 (5) pp. 558-568.

O'Riordan, T. and Hay, R., 1976. Environmental Impact Assessment. Farnborough: Saxon House.

Ortolano L., 1984. Environmental Planning and Decision-Making. Chichester: John Wiley.

Ottinger, R.S., et al., 1973. Recommended Methods of Reduction, Neutralization, Recovery or Disposal of Hazardous Waste. Washington Dc: Environmental Protection Agency.

Otway, H.J. 1973. Risk Estimation and Evaluation. In: International Institute for Applied Systems Analysis Planning Conference on energy systems. pp. 354-380. Baden, Austria, July 1973.

Otway, H.J., and P.D. Pahner. 1976. Risk Assessment. Futures. No. 8: pp. 122-134.

Otway, H. (1977). Present Status of Risk Assessment Paper presented at 10th International Conference on Risk Analysis: Industry, Government and Society. Rotherdam, Febravary 1977.

Oweis, Issas and P. Raj Khera, 1990. Geotechnology of Waste Management. London: Butterworth.

Parke, D. 1983. Limits and Constraints of Scientifically-Based Environmental Health Risk on Health and the Environment, 12-16 December, Vienna.

Parker, K.R. and Russell-Jones, 1986. A control of refuse incinerator particulate emission. Proceedings of the Institution of Mechanical Engineers. Vol 200 No. A1.

Parkinson, Michael, march 1990. The Boundary Commission's Proposals for the Metropolitan Borough of Knowsley: a response working paper No. 11. . Liverpool: University of Liverpool, Centre per Urban Studies.

Perkins, J.J. 1969. Principles a Methods of Sterilization in Health Sciences. Springfield. IL: Charles C. Thomas.

Porteous, Andrew, 1992. Incineration what prospects? Waste Management. April. pp. 193-202.

Powell, Fred C., 1987. Air pollutant emissions from the incineration of hospital waste. Journal of the Air Pollution Control Association. 37 pp. 7.

Prasartseree, M. 1982. A conceptual development of quantitative environmental impact assessment methodology for decision-makers. Journal of Environmental Management. No. 14: pp. 301-308.

Rasmussen G. F., and J.N. McFee, 1983. Fluidized B Incineration systems for the ultimate disposal of toxic and hazardous materials, Paper persented at the 1st Annual Hazardous Materials, Management Conference, Philadephia, Pa.

Rasmussen George F., Robert W. Benedict, Craigm Young. 1989, Fluidized-Bed Thermal Oxidation I Standard Handbook of Hazardous Waste Treatment and Disposal. Harry M. Freeman.(Ed). London: McGraw Hill.

Regens, J.L., T.M. Dietz, and R.W. Rycroft. 1983. Risk assessment in the policy- making process: environmental health and safety protection. Policy Administration Review. No. 3: pp. 137-145.

Reichelt, P. 1977. Central incineration: Disposal of pathological and infectious wastes and wastes similar to household refuse. Wasser, Luft and Betreib. No. 21 (12) pp. 47-49.

Reise D., 1990. Operation of a Separate Central Plant the Disposal of Hospital Refuse the Example of Kiel. Unpublished.

Repa, E.W.; and Kiser, J.V.L. 1988. Disposing ash. Waste Alternatives. 1 (2) pp. 74-79.

Riha, J., 1988. Total index of environmental quality as applied to water resources (Environmental Impact assessment, the recent Czechoslovak case study). *Risk assessment of chemicals in the environment*, M.L. Richardson (Ed.) pp. 373-377. London: Royal Society of Chemistry.

Robinson, J.D., M.D. Higgins and Bolyard P.K., 1983. Assessing environmental impact on health- a role for the behaviourial science. *Environmental Impact Assessment Review*. No. 4, pp. 41-54.

Rogers J.T. and AV. Bates. 1983. (Ed). *A Symposium on the assessment and perception of risk to human health in Canada.*

Roque, C.R., 1985. Environmental Impact Assessment in the association of southeast Asian Nations. *Environmental Impact Assessment Review*. No. 5 (3) pp. 257-263.

Rowe, D.W., 1977. *An Anatomy of Risk.* New York: John Wiley.

Rowe D., William, 1980. Risk assessment approaches and methods. In: *Society Technology and Risk Assessment*. J., Conrad (Ed). London: Academic Press.

Royal Society 1983. *Risk Assessment: Report of a Royal Society Study Group.* London: Royal Society.

Royal Commission on Environmental Pollution. 1976. Fifth report. London: HMSO.

Rubbo, S. D., and J.F. Gardner. 1965. *A Review of Sterilization and Disinfection.* London: Lioyed-Luke. Ltd.

Ruble, F. 1974. *Incineration of Solid Waste*. pp. 178-193. New Jersey: Noyes Data Group.

Ruckelshaus, W.D. 1983. *Science*. Vol. 221, pp. 1026.

Rutala, William; and Felix A., Sarubbi 1983. Management of infectious waste from hospitals *Infection Control*. 4(4) pp. 198-204.

Ryan, J.J.; R.Lizotte and B.P.Y.Lau, 1985. "Chlorine aced dibenzo-p-dioxins and chlorinated dibenzofurans in canadian human adipose tissue", *Chemosphere*. No. 14, pp. 697-706.

Sandman P.M., D.B. Suchsman, M.R. Greenberg, and M Gochfeld. 1987. Environmental Risk and the Press. New Brunswick Nj: Transaction publishers.

Satin, K.; Denae, M.; Leonard Neutra, R., Gravitz, N.; Harnly, M.; Green, R. 1983. The McColl Site Health Survey: An Epidemiological and Toxicological Assessment of the McColl Site in Fulleton, California.

Schecter, A.; Ryan, J.J.; Lizotte, W; Sun, L.; G. Gitliz and M. Bogda Sarian, 1985. Chlorinated Dibenzodioxins and Dibenzofurans in human adipose tissue from exposed and control New York Stat Patients. Chemosphere. No 14, pp. 933-937.

Schrenk, H.H., et al., 1949. Air pollution in Donora, Pa., , US. Public Health Service. Washington DC. Public Health Bulletin. No. 306

Schaumburg H.H, P.S. Spencer, J.C. Arezzo, 1983. Monitoring potential neurotoxic effects of hazardous waste disposal. Environmental Health Perspectives No. 48: pp. 61-64.

Schwing, R.C. and W.A., Albers, Jr. 1980. Societal Risk Assessment: How Safe is Safe Enough? New York: Plenum press.

Scott, D.W.; Woodfield, B.; and Webb, K., 1986. The Measurement of Suspended Particle, Heavy Metal and Selected Organic Emissions at the Coventry Municipal Refuse Incinerator. Stevenage: Warren Spring Laboratory.

Selye, Hans, 1976. The Stress of Life. London: McGraw Hill.

Shah, J.K.; T.J. Schultz, V.R. Daiga, 1989. Pyrolysis Processes in Standard Handbook of Hazardous Waste Treatment and Disposal, Freeman, H.M., (Ed). London: McCraw Hill.

Shen, T.T. 1981. Estimating hazardous air emission from disposal sites. Pollution Engineering. 13 (8) pp. 31-34.

Shepard, T.H., 1983. Catalog of Teratogenic Agents. 4th (Ed). Baltimore: Johns Hopkins University press.

Shrader - Frechette, K.S. 1985. Risk Analysis and Scientific Method. Dordrecht. Reidel

Sigler, Jeanne, 1973. Attitudes of Illinois Citizens Toward Solid Waste and the Environment. , Final report. pp. 73-76. Springfield: Illinois Institute for environmental quality.

Sjoberg, L. 1987. Ed. Risk and Society, Studies of Risk Generation and Reaction to Risk. London: Allen & Unwin.

Skitt, John. 1972. Disposal of Refuse and Other Waste. London: Charles Knight.

Slovic, P., B. Fischhoff and S. Lichtenstein, 1979. Perceived risk. Environment. No. 21 (3), pp. 14-20 and 36-39.

Slovic, p., B. Fischhoff and S. Lichtenstein, 1982. Risk Analysis. Vol 2: pp. 83.

Slovic, Paul 1987. Perception of risk. Science. Vol. 230: pp. 480-485.

Smith, L.T.; Matula, R.A.; and Tsou, F., 1975. Summary of Solid Waste Incineration and Energy Recovery in Hospital. Paper presented at the 68th. Annual Meeting of the Air Pollution Control Association. Denver, Colorado.

Smith, Allan H. 1987. Infant exposure assessment for breast milk dioxins and furans derived from waste incineration emission. Risk Analysis. 7(3) part 3, pp. 347-353.

Smith Keith, 1992. Environmental Hazards Assessing Risk & Reducing Disaster. London: Routledge.

Sloane, B.D. and Sherbine, C.A., 1988. Evaluation of off-normal release frequencies for a PcB incinerator under design. IEEE Transactions on Reliability, R-37 (2).

Sondheim, M.W., 1978. A comprehensive methodology for assessing environmental impact. Journal of Environmental Management; 6 (1) pp. 27- 42.

Sorensen, J.C. 1971. A Framework for Identification and Control of Resource Degradation and Conflict in the Multiple Use of the Coastal Zone. Berkeley, Ca. University of California a t Berkeley, Department of Landscape Architecture.

Spangler, M.B., 1987. In Advances in Risk Analysis, Vol. 4: Uncertainty in Risk Assessment, Risk Management, and Decision Making. V.T. Covotto, L.B., Lave, A. Moghissi & V.R.R. Uppuluri, P.I., (Ed). New York: Plenum press.

Starr, C., 1969. Social Benefit, Technological risk. Science. No. 165, pp. 1232-1238.

Stalling, D.L., et al., 1983. Residues of Polychlorinated Dibenzo-p-dioxins and Dibenzofurans in Laurentian Great Lakes Fish. In human and environmental risks of Chlorinated Dioxins and related compounds. R.E. Tucker, A.L. Young, and A.P. Gray (eds). New York: Plenum Press.

Stern Alan H.; et al., 1989. Potential exposure levels and health effects of neighbourhood exposure to a municipal incineration bottom ash landfill. Archives of Environmental Health. 44 (1).

St Helens & Knowsley Health Authority, Department of Community Medicine. 1988. The Winds of Change. St. Helens: St. Helens and Knowsley Health Authority.

Thor, E., 1978. Forest environmental impact analysis- a new approach. Journal of Forestry.; p 723-725.

Thibodeaux, L.J. 1981. Estimating the air emission of chemicals from hazardous waste landfills J. Hazardous Materials. No. 4: p. 235- 244.

Tillman, David A. Amadeo J.Rossi Katherine M. Vick. 1989. Incineration of Municipal and Hazardous Solid Wastes. London: Academic Press.

Tickell, Oliver; Watson, Alan, 1992. Hospital waste: A case for treatment. New Scientist. 28th March.

Tomlinson, P., 1987. Environmental audits special edition. Environmental Monitoring and Assessment. 8(3), pp. 183-261

Trenholm, A., R. Hathaway and D. Oberacker, 1983. Products of Incomplete Combustion from Hazardous Waste Incineration. pp. 84-96. Washington DC: Environmental Protection Agency.

Trenholm, A.; P. Gorman, G. Jungclaus, 1984.Performance Evaluation of Full-Scale Hazardous Waste Incinerators. Vol II, Washington DC: Environmental Protection Agency.

Turnbull, R.G., 1981. A Review of the Current Uk Practice in the Assessment of Major Planning Applications. Manchester University.

Turner, R.K., and O'Riordan, T., 1982. Project Evaluation. In: Environmental Science Methods, (Ed). Haynes, R., pp. 372-398. London: Chapman and Hall.

Turvey, R., 1990. Waste management and control the envisaged role of waste regulation authority. Waste Management 80 (10), pp. 775-786.

United Nation Economic Commission for Europe 1979. Environmental Impact Assessment Seminar Procedural and Institution Questions. Document Evn/Sem. 10/ R.1. Villach- Austria. September 1979.

United Nation Environment Programme, 1979. Guidelines for Assessing Industrial Environmental Impacts and Environmental Criteria for the Siting of Industry. (A draft). Nairobi, Kenya: UNEP.

US. Nuclear Regulatory Commission, 1975. Reactor Safety Study- an Assessment of Accident Risks in US. Commercial Nuclear Power Plants. Washington DC: Government Printing Office.

Wallin, S. and P. Clayton, 1985. Emissions and Pathways of Dioxins and Dibenzofurans from the Combustion of Municipal Refuse and Refuse-Derived Fuel, Hertfordshire. Stevenage: Warren Spring Laboratory.

Warner, A.J, C.H.Parker, and B. Baum. 1970. Solid Waste Management of Plastics. Washington DC: Manufacturing Chemists Association.

Warner, M.L. and E.H. Preston, 1974: A Review of Environmental Impact Assessment Methodologies, Washington DC: EPA.

Warner, M.L. and S.W. Bromley, 1974. Environmental Impact Analysis: A Review of Three Methodologies, Madison: Wisconsin University.

Washburn, Stephen, T.; Jennifer. Brainard and Robert. H. Harris. 1989. Human Health Risks of Municipal Solid Waste Incineration. In: Environmental Impact Assessment Review. 9 (3), pp. 181-198.

Waste Management Advisory Council: 1976. 1St report, London: HMSO.

Waste Management LTD. 1992. Personal communication.

Wathern, Peter. (Ed.), 1988. Environmental Impact Assessment, Theory and practice. London: Unwin Hyman.

Weinberger, Leon et al., 1984. Supporting Documentation for the RCRA. Incinerator Regulations. 40 CRF 265 Subpart 0-Incinerators. Washington DC: Environmental Protection Agency.

Welch, H.W. and G.D. Lewis, 1976. Assessing environmental impacts of multiple land management. Journal of Environmental Management. No 4, pp. 197-210.

Welsh Office, 1985. The Incidence of Congenital Malformations in Wales, Special Reference to the District of Torfaen, Gwent. Cardiff: Welsh Office.

Whyte, A., 1982. Environmental Hazards, In: Report to Government of Barbados on UNESCO/ UNFPA/ISER project in the East Caribbean. Barbados: University of West Indies.

Whyte, A., and Burton, I., 1982, Perception of Risk in Canada. In: Burton, I., C.D. Fowle and R.S. McCullough, (eds). Living with Risk. Environmental risk management in Canada. Toronto: University of Toronto.

Wilson. J.L., and P.J. Miller, 1978. Two-Dimensional plume in Uniform Groundwater Flow. Journal of the Hydraulics Division proceedings of the American Society of Civil Engineers. 104 (4): pp. 503-514.

Wilson, David, C., 1981. Waste Management Planning, Evaluation, Technologies. Oxford: Clarendon Press.

Wilson, David C. 1982. Balancing pollution costs and Risk-Theory and practice. In: Risk, Cost and Pollution 4th. Harwell Environmental Seminars. Harwell, April 1982.

William D., Robinson, P.E. (Ed.), 1986. The Solid Waste Handbook. London: Wiley.

Withers, John, 1988. Major Industrial Hazards : Their appraisal and control. Aldershot: Gower.

World Health Organization, 1979. Environmental Health Impact Assessment. Report on WHO Seminar. EURO reports and studies No 7, Copenhagen.

World Health Organization, 1982. International Agency for research on Cancer. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Vol. 4. 1-29.

World Health Organization, 1983. Selected Techniques for Environmental Management-Training Manual. Geneva: WHO.

World Health Organization, 1985a. Risk Management in Chemical Safety. Geneva: WHO.

World Health Organization, 1985b. Environmental Pollution Control in Relation to Development. Geneva: WHO.

World Health Organization, 1985c. Management of Waste from Hospitals. Euro reports and studies 97. Geneva: WHO.

Womann, Heinz, 1971. Experiences with Industrial Waste Incineration at BASF. Energie 23 (11).

Woodfield M. 1987. The Environmental Impact of Refuse Incineration in the UK. Stevenage: Warn Spring Laboratory.

Yanchinski, S. 1989. New analysis links dioxin to cancer. New Scientist 28th October 1989. pp. 24.

APPENDIX 1

Ali J. Mosavi
Environmental Resources Unit,
Salford University,
Salford,
M5 4WT.
Tel : 061 -745 5000

Dear Sir/Madam

I am doing research at the University of Salford into the public's perception of incinerator installations in particular hospital incinerators.

I am writing to ask if you would be willing to participate in this study, which is being carried out in the Environmental Resources Unit on the University of Salford.I would be most grateful if you could spare a little of your time to answer this questionnaire. It asks you about your own experiences and opinions about incinerator installations and other related information.

All replies will be regarded strictly confidential, and only statistical totals will be used in the study.

Thank you very much for your co-operation, and I would appreciate any help you could give toward my study as well. If you have any questions or would like further information please contact me at the above address.

Yours faithfully

Ali J. Mosavi

Questionnaire into the public's perceptions of Incinerator Installations.

Biographical Information.
Please answer each of the following questions.

1- Name ....

2- Address ....
....
....

3 - What is the name of the district you live in?
....
....

4 - a. How long have you been living here?
....

b. Why did you come to live in Kirkby?
....

5 - Age.....................Years.

6 - Sex? Please tick the appropriate box.

Male [ ]
Female [ ]

7 - a. Marital Status: Please tick the appropriate box.

Single [ ]
Married [ ]
Co-habiting [ ]
Divorced [ ]
Widowed [ ]
Separated [ ]

b - If married, does your partner work?

Yes [ ]
No [ ]

c - If yes, does He/She work?

Full-time [ ]
Part time [ ]

8 - Have you any children?
Yes [ ]
No [ ]

If yes, please write in the ages of your children?

Boys	Girls

9 - How many people live in your house, including yourself?
Number ....

10 - How many years have you had full- time education?
....

11- What level of education have you received?
....

12- What is your income per year?
....

13 - a. Do you have any job?

Yes [ ]
No [ ]

b- If yes, how many hours per week.
....

14- Do you find time to relax and "wind down"?
Please tick the appropriate box .

Always [ ]
Sometimes [ ]
Only when possible [ ]
Not usually [ ]

15 - Do you have a hobby or interest?

Yes [ ]
No [ ]

16 - Do you exercise?
Please tick the appropriate box .

Always [ ]

Sometimes ,when possible [ ]
Now and again [ ]
Not usually [ ]
Never [ ]

17 - a. Do you smoke?

Yes [ ]
No [ ]
b . If yes, please give more detail.

	Cigarettes	Cigar	Pipe	Other	
Amount	----	----	----	----	Number per day

18 - a. Do you drink?
Yes [ ]
No [ ]
b. If yes, how many days per week? ....
c.Average quantity per day? ....

19 - a. Have you encountered any traumatic events over the past year
(for example, death of relatives, moving)?
Yes [ ]
No [ ]
b.If yes, please outline.
....
....
....
....
....
....
....
....

20 - Which paper do you read normally?
Guardian [ ]
Times [ ]
Mail on Sunday [ ]
Sunday Telegraph [ ]
Sunday Express [ ]
Sunday Observer [ ]
Daily Star [ ]
Manchester Evening [ ]
Morning Star [ ]
Mirror [ ]
Mail [ ]
Express [ ]
Telegraph [ ]
Other [ ]

21 - a. Do you know that there is a project for the establishment of hospital incinerator in your area?

Yes [ ] No [ ]

b. If yes where did you get the information?

Newspaper [ ]
Friends [ ]
Leaflets [ ]
T.V. [ ]
Person giving a talk. [ ]

Please answer the following questions.You should give your answer by ticking one of the possible alternatives. Before ticking a choice, make sure you know which is the end of a question.

1- How do you feel about the Kirkby area at present?
Please tick the appropriate box.
Very satisfied [ ]
Fairly satisfied [ ]
Quite dissatisfied [ ]
Very dissatisfied [ ]
Don't know [ ]

2 - Do you feel that you have any trouble about your general health and physical fitness ? Please tick the appropriate box.
A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

3- Do you ever have any trouble getting to sleep?
A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

4- Have you ever been troubled by nervousness,feeling fidgety or tense?
A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

5 - Have you ever been troubled by eye irritation?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

6 - Are you ever troubled by respiratory symptoms?
(a bad chest, coughs, wheezing, short breath)

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

7- Are you ever troubled by headaches?

A lot [ ]
Quite often [ ]
Occasionally [ ]

8- Have you ever been bothered by having an upset stomach?

A lot [ ]
Quite often [ ]

Occasionally [ ]
Never [ ]

9- Do you find it difficult to get up in the morning?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

10- Have you ever been bothered by your heart?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

11- Do you ever have spells of dizziness?

A lot [ ]
Quite often [ ]
Never [ ]

12 - Do your muscles ever tremble (e.g. hands tremble, eyes twitch)?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

13 - Do you feel mentally used up and have difficulty in concentrating?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

14 - Do you feel you are bothered by all sorts of aches and pains in your body?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

15 - Do you suffer from skin irritation, rashes or spots?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

16 - If you suffer from any of these symptoms do they get better when go on holiday?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

17 - Do you have any health problems caused by toxic materials which industrialists use near your residence?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

18 - Do you think that an incinerator in the vicinity of your house would be a problem for you?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

19 - Do you sometimes worry about the incinerator?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

20 - Do you think that chemical incineration causes problems for your health?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

21 - Do you think living in Kirkby is the cause of any of your ailments?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

22 - Have you ever felt any problem from the amount of traffic round your house or flat?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

23 - Do you ever experience nasty smells from factories in your area?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

24 - Do you suffer from smells coming from lorries in your area?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

25 - Have you ever seen any fumes from factories near where you live?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

26 - Do you think ,the lorries cause any problems for the children?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

27 - Are you satisfied with cleanliness of your environment?

Yes [ ]
No [ ]
Don't know [ ]

28 - Are you satisfied with the appearance of your area?

Yes [ ]
No [ ]
Don't know [ ]

29 - How much do you think factories damage the environment?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

30 - Do you experience any trouble from sounds and noises from factories?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]

31 - Do you know whether there are any incinerators in your area?

Yes [ ]
No [ ]

32 - a. Do you know what is emitted from an incinerator's chimney?

Yes [ ]
No [ ]

b. If yes, please give more details.

....
....
....
....
....
....

33 - a. Do you know anything about the effects of emissions from an incinerator's chimney upon children's health?

Yes [ ]
No [ ]

b. If yes, how great is the effects?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Nothing [ ]
Don't know [ ]

34 - a. Do you know what the effects of emissions from an incinerator's chimney are upon the health of elderly people?

Yes [ ]
No [ ]

b. If yes, how great are the effects?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Nothing [ ]
Don't know [ ]

35 - a. Do you know what the effects of emissions from an incinerator's chimney are upon animals?

Yes [ ]

No [ ]

b.If yes, how great are the effects?

A lot	[ ]
Quite often	[ ]
Occasionally	[ ]
Nothing	[ ]
Don't know	[ ]

36 - a. Do you know what the effects of emissions from an incinerator's chimney are on upon pregnant women?

Yes	[ ]
No	[ ]

b. If yes, how great are the effects?

A lot	[ ]
Quite often	[ ]
Occasionally	[ ]
Nothing	[ ]
Don't know	[ ]

37 - a. Do you know what the effects of emissions from an incinerator's chimney are upon food?

Yes	[ ]
No	[ ]

b. If yes, how great are the effects?

A lot	[ ]
Quite often	[ ]
Occasionally	[ ]
Nothing	[ ]
Don't know	[ ]

38 - a. Do you know what the effects of emissions from an incinerator's chimney are upon the atmosphere?

Yes	[ ]
No	[ ]

b.If yes, how great are the effects?

A lot	[ ]
Quite often	[ ]
Occasionally	[ ]
Nothing	[ ]
Don't know	[ ]

39 - a. Do you know what the effects of emissions from an incinerator's chimney are upon trees?

Yes [ ]
No [ ]

b. If yes, how great are the effects?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Nothing [ ]
Don't know [ ]

40 - a. Do you feel concerned about living in the vicinity of an incinerator?

Yes [ ]
No [ ]

b. If yes, how great is your concern?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Nothing [ ]
Don't know [ ]

41 - Do you know anything about hospital incinerators?

Yes [ ]
No [ ]

42- Do you think that hospital incinerators cause problems for health?

A lot [ ]
Quite often [ ]
Occasionally [ ]
Never [ ]
Don't know [ ]

43 - a. Do you think that is a good idea to build a hospital incinerator close to your residence?

Yes [ ]
No [ ]

b. If no, have you any reason?

....
....
....

44 - Is it advisable to build a hospital incinerator close to fields of from crops?

Yes [ ]
NO [ ]

45 - Would you participate in any action that is against the implementation a hospital incinerator?

Yes [ ]
No [ ]

46 - What advantage is it to have a hospital incinerator in your area?

Employment [ ]
Improvement of economy [ ]
Disposal of hospital waste in a healthy way [ ]
Use in medical science [ ]
Other [ ]
Don't know [ ]

47 - a. If a hospital incinerator was to be build close to your area, would you move away?

Yes [ ]
No [ ]

b. If yes please give the reasons for your decision?

....
....
....
....

48 - How far away from your house do you think the hospital incineration should be?

Less than 10 Miles [ ]
10 Miles [ ]
20 Miles [ ]
30 Miles [ ]
40 Miles [ ]
More than 50 Miles [ ]

Thank you for your help.

A SURVEY TO ASSESS THE IMPACT OF THE INSTALLATION OF A HOSPITAL INCINERATOR ON THE LOCAL COMMUNITY (IN KIRKBY).

PLEASE DO NOT TAKE ANY NOTICE OF THE FIGURE IN THE RIGHT HAND COLUMN. THEY ARE FOR STATISTICAL PURPOSES.

	Code
Age.............. Years	4-5

Please circle around your answer.

Sex:	Male	1	Female	2	6

Education level:

Primary	Secondary	Higher education	University	
1	2	3	4	7

1. How often have you been concerned about the following problems during the past year?

	Very often	From time to time	Not much at all	Don't know	
a. Crime	1	2	3	4	8
b. Accidents	1	2	3	4	9
c. Smoking	1	2	3	4	10
d. Risks at work	1	2	3	4	11
e. Industrial pollution	1	2	3	4	12
f. Hospital Incinerator	1	2	3	4	13
g. Traffic	1	2	3	4	14

2.a. Are you aware that there is a project for installing a hospital incinerator in your area?

Yes	1	No	2	15

b. If yes, how did you get the information?

Newspaper	1	16
Friends	2	17
Leaflet	3	18
T.V	4	19
Other	5	20

3. If a hospital incinerator was built in Kirkby, what problems do you think might occur?

	Very Serious Risk	Moderate Risk	Not serious Risk	Don't know	
a. Fire	1	2	3	4	21
b. Explosion	1	2	3	4	22
c. Water pollution	1	2	3	4	23
d. Soil contamination	1	2	3	4	24
e. Odour (Smell)	1	2	3	4	25
f. Noise	1	2	3	4	26
g. Air pollution	1	2	3	4	27
h. Hazards from big lorries	1	2	3	4	28

i. Other (please specify)	1	2	3	4	29

4. How often have you been concerned about the following problems over the last year?

	Very serious Concern	Moderate Concern	Not serious Concern	Don't know	
a. Your general health	1	2	3	4	30
b. Eye irritation	1	2	3	4	31
c. Tension	1	2	3	4	32
d. Respiratory symptoms (breathing)	1	2	3	4	33
f. Skin irritation	1	2	3	4	34

5.a. Are you concerned about the prospect of living near a hospital incinerator?

Yes	1	No	2	35

b. If yes, how great is your concern?

Very great	1	36
Moderate	2	37
Slight	3	38
Not at all	4	39

6. Do you think that FACTORIES in your area cause any serious problems for the following:

	Very serious problem	Moderate problem	Slight problem serious	Not serious problem	Don't know	
a. Elderly people	1	2	3	4	5	40
b. Pregnant women	1	2	3	4	5	41
c. Children	1	2	3	4	5	42
d. Crops	1	2	3	4	5	43
e. Animals	1	2	3	4	5	44
f. Environment	1	2	3	4	5	45
g. Others	1	2	3	4	5	46

7. Do you agree that if would be good to install a hospital incinerator close to your residence? 47

Yes	1
No	2

8. Would you participate in any action that was taken

against installation of a hospital incinerator? 48

Yes	1	
No	2	

9. What are the advantages of having a hospital incinerator in your area?

a. Employment	1	49
b. Improvement of economy	2	50
c. Disposal of hospital waste in a healthy way	3	51
d. Use in medical science	4	52
e. None	5	53
f. Don't know	6	54

10. If a hospital incinerator is to be built close to your area, would you wish to move away? 55

Yes	1
No	2

11. How far away from your house do you think the hospital incinerator should be?

a. Close	1	56
b. Far	2	57
c. Very far	3	58
d. Don't know	4	59

12. Do you think that HOSPITAL INCINERATORS cause any problems for the following:

	Very Serious problem	Moderate problem	Slight problem serious	Not serious problem at all	Don't Know	
a. Elderly people	1	2	3	4	5	60
b. Pregnant women	1	2	3	4	5	61
c. Children	1	2	3	4	5	62
d. Crops	1	2	3	4	5	63
e. Animals	1	2	3	4	5	64
f. Environment (water, plants...)	1	2	3	4	5	65
g. Others	1	2	3	4	5	66

THANK YOU FOR YOUR CO- OPERATION.

APPENDIX 2

Friday 31 May 1991 Independent

Hospitals criticised on burning of waste

By Susan Watts
Science Reporter

HUNDREDS of hospital incinerators are burning medical waste at temperatures too low to break down hazardous pollutants, waste disposal contractors say in a report published today.

The National Association of Waste Disposal Contractors (NAWDC), whose members represent 60 to 70 per cent of the industry, says that Britain must end the "shabby" standards that have allowed hospitals to fall behind technical advances in disposing of waste safely.

Hospital incinerators are not checked by the Government's pollution inspectorate, nor are local environmental health officers obliged to check emissions. The association says this means high levels of pollutants such as heavy metals, acids, dioxins, dust and sulphur are being belched into the air.

The association says that most of the estimated 800 plants used by health authorities cannot burn waste at the required temperature, have no gas cleaning system and no chimney of sufficient height to disperse fumes.

David Boyd, its director of industrial affairs, said: "Never in the 21-year history of NAWDC has the association come across an area of waste management where the current practices are so appallingly below standard."

The Department of the Environment has said small hospital incinerators need not comply with its latest emission standards, which are less strict than those recommended by the association today, for another five years. Until last month hospitals also had Crown immunity, so they could not be prosecuted for poor standards of emissions.

The association wants the Government to make it illegal to dump clinical waste from veterinary surgeries, dentists and pharmacies as well as hospitals on land-fill tips. It says such waste should be segregated at source, packaged, labelled and handled as hazardous waste and stored and transported in special containers. It also wants Her Majesty's Inspectorate of Pollution to enforce new standards for emissions.

Mr Boyd fears that its new guidelines will bring the association up against the Office of Fair Trading which may deem them anti-competitive. If all the association's members agree to its new practices, customers could have less freedom to use contractors whose processes would still be legal. "The law will indeed be an ass if we were to be penalised for exposing a currently unsatisfactory position and offering an environmentally sound solution to a considerable problem," Mr Boyd said.

He quoted a select committee survey last year of incinerators in Wales, which found that only two out of 36 health authority plants used any form of air cleaning equipment, and only 10 burnt the waste at sufficiently high temperatures. None monitored the emissions from their chimneys. Mr Boyd believes this picture is reflected throughout Britain.

He said it would be far cheaper for the taxpayer if hospitals were to send only their most dangerous waste to private contractors for high temperature incineration, than for local authorities to spend thousands of pounds upgrading each of their small plants to meet stricter standards.

Page Six Kirkby Challenge, March 1989

Challenge

Waste incineration and Kirkby . . . continued

OUR readers will have been *surprised and disappointed to* hear about a new proposal to build a waste disposal incinerator plant, this time actually within Kirkby. They could be forgiven for thinking that successful public opposition to the earlier, different scheme for an incinerator at Gillmoss had closed the door on the whole matter.

About the only good thing to say about the suggested Hammond Road site is that the prevailing wind would blow the smoke away from Kirkby, not over it, unlike the abortive Gillmoss project. But winds change in direction, and occasionally do not blow at all, leaving the heavier particles in smoke emmisions (possibly Dioxins) to come to rest within a small radius of the plant.

Even more alarming is the prospect of lorries carrying up to 200 tonnes of medical waste from Merseyside and Cheshire per week travelling over our roads. The disclosure that used syringes will be included in this hazardous cargo causes especial concern, because of all the publicity about A.I.D.S. and drug abuse. What provision would be made for the security of this waste, both in transit, and at the plant itself prior to its disposal?

Surely under the circumstances, the incineration of these materials at source — i.e. at the hospitals themselves — would be preferable. And if there are objections to this because hospitals are located in or near high-density population areas, doesn't the same argument apply to the Hammond Road site, which will be situated just a little over half-a-mile from the edge of the main Kirkby residential area?

THE NEW YORK TIMES, SUNDAY, JANUARY 8, 1989

Alternatives to Incinerators Sought

Continued From Page 1

burning. "The D.E.P. didn't select incineration; the counties did," he said. "Now we're holding their feet to the fire to carry out the plans they put forward."

New Jersey has only one county facility in operation (the Warren County plant) and three others under construction (in Camden, Gloucester and Essex Counties). However, Dr. Donald A. Deieso, an assistant commissioner of the Department of Environmental Protection, expects the state to meet its deadline for self-sufficiency, with as many as 15 incinerators in operation within the first six to eight months of 1992.

To illustrate the cumulative impact of these incinerators, Assemblyman Rocco's office has drawn a map with a 10-mile radius around the sites selected to indicate the area of greatest exposure to potentially hazardous ash and acid gas emissions.

While incinerator fallout depends on the kind of emission control equipment installed at a plant, the size of a plant's smokestack and differences in climate, an aide to Mr. Rocco, Francis Rapa, said the area on the map was based on data compiled from Federal reports and scientific research, some of which indicate that emissions can travel as far 20 to 25 miles.

But Dr. Deieso, who has been outspoken about those who he says "scare residents with lies and distortion," said that the map had no basis in fact and that his agency's regulations required the most advanced technology available to minimize emissions in the area around an incinerator.

Whether or not the proposed moratorium becomes law, halting a process already marked by years of delay and antagonism between proponents and critics of incineration, the bill comes at a time when less costly, nonburning alternatives are being put forth and several county officials are beginning to express second thoughts about their original plans.

One emerging technology highly touted by Mr. Rocco and others is the ORFA process, which takes unseparated garbage and converts most of it into a reusable fiber for paper products without burning or burying any of the trash. With only a prototype plant in Switzerland, the ORFA Corporation of America opened its first full-scale commercial plant in Philadelphia last year.

Besides maintaining that it is environmentally safe, Mr. Rocco said the the greatest benefit of the ORFA process was that the plant would be built with private money, by the corporation that developed the disposal process, and not require county bond issues of $50 million to $100 million. In addition, estimated fees for dumping garbage at the plant would be half that anticipated for incinerators.

Last spring, Mr. Rocco persuaded the Camden County Freeholders to halt progress on the county's two incinerators for three months in order to evaluate the ORFA facility, but changing the county's solid-waste plan was rejected because the technology was considered too unproven and the financial consequences of abandoning incineration were considered too great.

State environmental officials have also looked at the ORFA process but express doubts about its viability as a solution in New Jersey, questioning the product's marketability. They have also cited the fact that the Philadelphia plant, which was built to process as much as 400 tons of garbage a day, has yet to handle that volume of waste.

But Mr. Rocco continues to push the ORFA method, although Camden County has broken ground for its two incinerators. "I can't understand why they're opposed to it besides that they've spent so much money already and don't want to look at alternatives," he said.

Construction on the county's Pennsauken incinerator has been halted pending a ruling by the Federal Environmental Protection Agency about its emissions control equipment, but officials are seeking to upgrade the plant, not alter their plans.

More Intensive Recycling

For the most part, other disposal alternatives are based on more traditional recycling practices — source separation of wastes, curbside collection, large-scale material processing centers, composting of food and yard waste, market supports for recycled goods, and public education — but apply them more intensively in order to pull out a higher volume of waste for re-use.

For example, a new study outlines how Union County, which buries none of its waste locally, can recycle 60 percent of its waste using proven technology and procedures. The county is planning to build a 1,400-ton-a-day incinerator, but does not have final permits and is facing a lawsuit over the site chosen for the plant.

Completed by the Institute for Local Self-Reliance, a Washington-based advocacy group that works with local communities, and financed by a grant from the Geraldine R. Dodge Foundation, the report offers a comparative analysis of the economic and environmental costs of incineration and an alternative method. That method includes recycling and recovering materials for a refuse-derived fuel product that can be burned more safely in existing industrial boilers.

"Maximizing recycling," the study concluded, "would eliminate the mass-burn incinerator and drastically reduce the environmental and public health impacts of solid-waste management."

The analysis also indicated that putting in place such a plan would cost about a third of the $105 million price tag for the county's incinerator.

Based on Effective Programs

And while state officials contend that most large-scale recycling plans are "based on what people believe will happen," the institute's co-founder and solid-waste expert, Neil Seldman, said the data in the study were based on recycling programs around the country that have been effective, although nothing as large or as comprehensive has been put into effect in a single community.

But a recent experimental 10-week intensive recycling program with 100 families in East Hampton, L.I., was able to convert 84 percent of its waste into compost and recyclable materials. Although based on a small sample, a report released last month suggested that to be cost-effective and facilitate marketing, the system should serve a minimum population of 100,000.

Developed by the Center for the Biology of Natural Systems at Queens College in New York, directed by Barry Commoner, a similar program is being put into effect in Buffalo, a city of 250,000.

While praising the program, Commissioner Daggett was not ready to abandon burning. "I can give you both sides of the argument," he said. "If you build incinerators, you won't have the incentive to achieve 60 percent recycling, but what do you do while you're trying to reach that level?" ■

HOSPITAL WASTE PLAN 'NO THREAT' — CHIEF

By Echo reporter

A TOP Belgian businessman has flown into Britain to allay fears about plans for a medical waste incinerator on Merseyside.

Jean Vandewalle told a press conference that his company would build the plant to the highest European safety standards.

Meanwhile, a local councillor has underlined his opposition to the £1m scheme on Kirkby industrial estate.

Knowsley Council Labour member Maurice Lee declared: "We need this thing like we need a hole in the head.

"I don't believe these people are coming here for the benefit of Kirkby and it will create very few jobs."

Even though few people live near the site, there could still be a risk to workers at adjoining factories if anything went wrong, said Cllr Lee.

Mr Vandewalle, managing director of the Belgian Incinerator Company NV, was brought over by Waste Management Ltd, which has submitted a planning application for the plant.

It would be built on the company's present transport depot on Hammond Road, Kirkby, and would deal with hospital waste from throughout Merseyside and Cheshire.

Mr Vandewalle said the plant, which could be operating in 18 months would meet EC regulations on pollution and emission controls.

Waste Management top brass told journalists at their headquarters in Rixton that the public had nothing to fear.

The potentially infectious waste including dressings and syringes are stored in plastic drums at the hospital which cannot be re-opened once sealed.

The drums are stored in refrigerated containers and taken by refrigerated truck to the plant for burning.

Page Six Kirkby Challenge, March 1989

INCINERATOR
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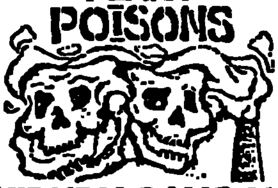
POISONS



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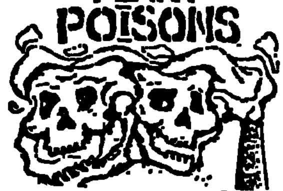

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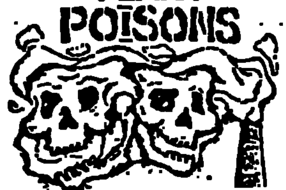

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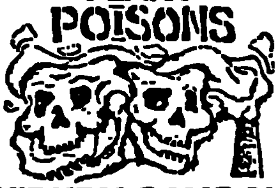

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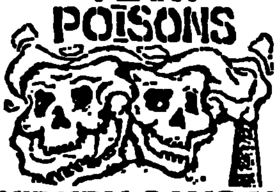

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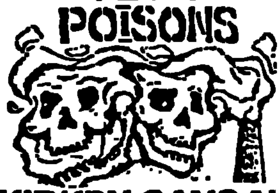

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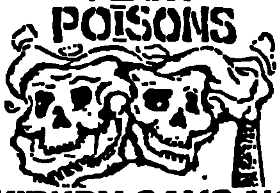

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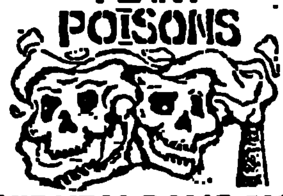

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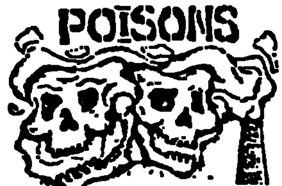

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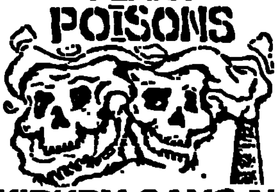

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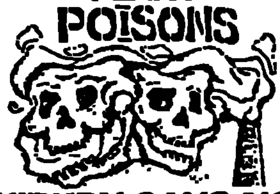

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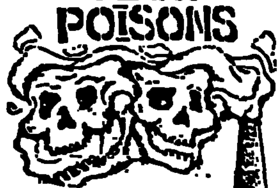

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