TABLE OF CONTENTS
Volume 1

I. INTRODUCTION

Industrial crises are becoming important because of their increased frequency, the extensive damage they cause, and their cost to organizations and society. More importantly, there seems to be an inexorable systemic logic in industrial societies that makes these crises almost inevitable. Industrial technologies are becoming progressively more complex and potentially harmful. ...Organizations are becoming larger in size and scope. As the Chernobyl nuclear disaster illustrates, the impacts of industrial crises sometimes transcend organizational and national boundaries to create harm on a global scale. (Shrivastava, Mitroff, Miller and Miglani 1988)

This document is one of a series of three carried out by independent consultants on behalf of the United Nations Centre for Urgent Environmental Assistance (hereafter described as "UNCUEA" or "the Centre") following the UNEP Governing Council Decision UNEP/GC.17/26. The three reports aim to highlight possible gaps in the existing international response capability and to identify areas for improvement, in particular with regard to the UN system. The Governing Council Decision asked UNCUEA to *analyze all international response systems and capacities, to assess the ability of the United Nations and other organizations to respond to environmental emergencies and to identify the main gaps, based on a review of major disasters that have occurred in the last ten years.* This report reviews major disasters and emergencies involving hazardous substances that have occurred in the last ten years in developing countries and countries in economic transition. It is not attempting to provide an exhaustive list of such accidents; nor does it purport to be definitive. It attempts to provide an overview of a problem that many people assume exists but which to date has not been sufficiently analyzed and described.

1.2 Scope

The Governing Council requested that analyses be undertaken relative to "different types of emergencies leading to environmental damage", to "environmental emergencies" and to "major disasters". Such broad reaching definitions include a variety of types of "emergencies" , with different causes and effects. Appendix I illustrates the range of potential incidents that could fall under such an umbrella term as "environmental emergency".

It was decided the report should focus on a small subset of environmental emergencies; industrial and other accidents involving the non-marine release of hazardous substances, excluding nuclear accidents. This includes the releases resulting from production, use, storage, handling, transport and disposal of hazardous substances. Several reasons were highlighted for this decision

- some environmental emergencies are already covered by specific international conventions and that relevant organizations have already introduced mechanisms for responding to such emergencies. e.g. the International Maritime Organization (IMO) deals with serious marine oil pollution incidents and radiological incidents fall under the remit of the International Atomic Energy Agency (IAEA).
- the terms of reference that were established for the Centre during its initial experimental phase highlighted sudden man-made emergencies.
- the need to narrow the scope of the report in light of time and resource constraints.

1.3 Methodology

To examine the situation outside the OECD countries two main sources of information were consulted; existing international databases and questionnaires and letters were sent to potential client countries (all developing countries and countries in economic transition) through

Government sources along with UNCUEA provisional National Focal Points, Infoterra Focal Points, UNEP Regional Offices and United Nations Development Programme (UNDP) Resident Representative. Additionally, over fifty relevant international sources were contacted for information. (Appendix II). These included accident databases, governmental and academic institutions, international organizations, non-governmental organizations, insurance companies, and trade press. The aim was to identify, if possible, accidents involving hazardous substances about which sufficient detail is available to allow an analysis. The information requested included:

- location, date and type of accident or incident
- extent and environmental impact of the incident
- the response mechanism employed at the local, regional and national levels
- an indication of any requests for international assistance
- the success or otherwise of any subsequent mission
- contacts for further investigation

The questionnaire specifically asked for information on accidents that had occurred " *with the potential for causing damage to the environment for which assistance from outside the country was sought or, in retrospect, was needed for an appropriate response*".

Chapter 1 of this report provides details on the scope, methodology, problems identified with the study and a brief examination of the major terms used.
Chapter 2 provides background information to place the following results into context, this section includes a brief overview of chemical emergencies in relation to other disasters and examines emergency response in developed countries. This includes the model approach and also some of the problems of response in the developed world. The social context of chemical emergencies and disasters in developing countries is briefly explored, to ensure that the problem is not seen as a purely technological or organizational one. The development of a disaster in a developing country is examined with a case study of the Bhopal disaster.
Chapter 3 examines the results of the database survey and highlights some of the inherent problems discovered.
Chapter 4 identifies the lessons learned from the national responses in terms of ability to respond to technological accidents. Case studies are used to illustrate the points identified from the questionnaire and letter responses.
Chapter 5 examines some other emergency scenarios which must be considered; the relationships between natural and technological disaster and the implications of conflict and civil strife.
Chapter 6 suggests possible future trends.
Chapter 7 provides conclusions and recommendations for consideration.

1.4 Problems inherent in the study

Several potential problems can be identified as resulting from restricting the study to accidents involving hazardous materials that caused, or threatened, environmental damage and where international assistance was required:

- Other important aspects of environmental emergencies are ignored, at least for the purposes of this report, for example effects of population displacement, major fires, natural disasters etc.
- By narrowing the scope to just emergencies involving chemicals that threaten environmental damage, there is a danger of forgetting that all chemical emergencies need adequate response; the eventual impact, whether humanitarian or simply environmental, is not the prime consideration during the initial response phase. The first priority of any response organization is to contain and neutralize the threat. Only after the incident has been brought under control can specific areas of interest such as health or environmental impact be addressed.

- Further narrowing the scope to the very small subset of incidents where external aid would have been appropriate can also lead to confusion because this assumes the responders can recognize an environmental threat and are therefore able to report it. Also this assumes that information on the range and type of bilateral or multilateral service available is accessible within the potential client country.
- Such recognition of environmental damage is in itself a difficult point; there is no internationally agreed definition of chemical accident severity. Therefore different responders will have different perceptions of an environmentally significant accident.
- It is important to note also that what might start as a simple minor emergency can easily escalate into a disaster if inappropriate action is taken. (for example see Case Study no. 12, page 34). Therefore, one must start from the premise of a country's ability to respond to the range of chemical emergencies. Only when the relatively simple emergencies can be adequately dealt with by developing countries can we reasonably expect to improve their ability to respond to disasters. Therefore, this review is not restricted to major international disasters but to any incident deemed sufficiently major by the local responder. This approach can attempt to gain an impression of a nations ability to respond to chemical emergencies in general and therefore provide an indication of how far they need to improve to be able to tackle disasters.

Lagadec noted some of the general problems inherent in such a study; *no study of crisis takes place without some unexpected upsets. The very field of analysis is full of deep and solid apprehension. If you look at crises and try to understand them , you may often stumble across unwritten rules, murky balances of power, or even buried secrets. There may not even be any deplorable intention to cover up the truth. The simple fact seems to be that people and institutions need a certain degree of secrecy in order to function. Consequently, collecting data is always an adventure, and often a discouraging one. But if those involved in the process remain clear about the outlook - that is, they acknowledge the complexity of the issue - then it is possible to make both pertinent and useful progress.* (Lagadec 1993).

1.5 Terms

"Emergency involving hazardous substances", "chemical emergency", "chemical accident" are used interchangeably to refer to the unexpected release of a hazardous substance excluding releases into the marine environment, which has caused or threatens to cause environmental damage. For the purposes of this document, the term hazardous substances refer to the type of substances that are within the scope of such international instruments as the UN/Economic Commission for Europe (ECE) Convention on the Transboundary Effects of Industrial Accidents (1992), the International Labour Organization (ILO) Convention and Recommendation on the Prevention of Major Industrial Accidents (1993), and the European Communities Council Directive on the Major Accident Hazards of Certain Industrial Activities ("Seveso Directive") (1982), as amended).

"Emergency", "accident", "incident" and **"event"** are used in the normally understood sense, without the rigid distinction made by some specialists.

"Disaster" a disaster is defined by the Department of Humanitarian Affairs (DHA) as "*a serious disruption of the functioning of society, causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using only its own resources*".(DHA 1992). This implies that a "disaster" could exist when the response capability of the country is overwhelmed. For example, the Swedish National Board of Health and welfare define a disaster as *a situation when there is an imbalance between the acute needs and the locally available resources.* (Norberg 1992). In many developing countries with little or no chemical response capability such a situation could arise very frequently. It should be recognized that what might be seen as a "minor" incident in the developed world is likely to be seen as a "major" emergency or even a "disaster" in a developing country in terms of ability to respond. Therefore the definition of incidents for inclusion in such a review is very difficult and relies on the views of the responder.

"Emergency", "Crisis", "Disaster" For the purposes of this paper an emergency can develop into a crisis when something fails in the response activity. This, if not checked, can easily escalate into a disaster whereby the ability to cope is exceeded. If, however, the crisis can be handled appropriately then the disaster can be averted. It is through the use of adept crisis management that the tide can sometimes be turned. It is accepted that in some circumstances the event will overwhelm ability to respond no matter what management techniques are on hand. It must be noted that disasters and emergencies are very different and planning for them requires two approaches. Professor Enrico Quarantelli, from the Disaster Research Center at the University of Delaware in the USA, draws a military analogy: *The military draws a distinction between strategy and tactics. The former has reference to the overall approach to a problem or objective. But there are always some situational factors or other contingencies which require particular adjustments to attain a specific goal if the overall objective is to be attained. This is the area of tactics. In somewhat parallel terms good disaster planning involves the general strategies to be followed in readying for disasters. In good crisis management, particular tactics are used to handle the situation contingencies which are present or which arise during the course of the emergency (Quarantelli 1992).* In broad terms this distinction is important; however, it must be recognized that an ability to manage disasters at the strategic level implies that the tactical requirements are in place and that countries can respond adequately to "smaller" chemical emergencies. If a country cannot cope with such emergencies, there is little hope they will be able to cope with disasters.

"**Response**" refers to any action taken to manage an emergency, during its occurrence and afterward, in order to reduce its negative effects on human health, welfare, economic activities and the environment. Emergency response is part of a recognized "disaster management cycle" which includes Prevention, Preparedness, Response and Recovery. It is useful to distinguish four phases of response: immediate initial assessment of the situation and control of the release (or prevention of further releases); containment of the substance released to limit adverse effects; post-emergency assessment of the environmental damage caused by the release (and mitigation of the damage), and clean-up/decontamination and rehabilitation of air, water and soil and other elements of the affected environment.

2. BACKGROUND

The spreading potential for cataclysmic outcomes, and the difficulty of forecasting and avoiding their occurrence, creates the likelihood that modern societies will be faced with a series of disasters that will be costly in terms of capital and lives. The odds are complicated by the further possibility that cataclysm might occur as a spiral of interlocking events and processes, [unfortunately] our understanding of low probability/high consequence events...is highly conjectural and inconclusive. (Orr, 1979, quoted in Showalter and Myers 1992).

2.1 Chemical emergencies in context

There are tens of thousands of chemicals in use throughout the world; every year thousands more are added to the more than four and a half million types registered by *Chemical Abstracts*. (Quarantelli 1992). It is inevitable that accidents will happen involving the production, transportation and use of such chemicals. And as the use of chemicals increases, the probability of accidents increases with it. In developing countries where the regulatory, technical and social controls over chemical safety are less stringent than the developed countries, the increase in chemicals use will not be accompanied by the increases in legislation and safety technology that increasing consumption brings in the developed world. It is likely that accidents will happen more frequently and with greater impact than before. The effects of such accidents will include severe human suffering and both short and long term implications for the environment; for water, soil and atmosphere.

At the moment ,from the available statistics, chemical accidents in developing countries appear to be both rare and of limited impact with a small number of notable exceptions such as Bhopal. For example since 1950, the available data would suggest that apparently there were only 13 acute chemical disasters in developing countries of sufficient magnitude to have resulted in more than 100 fatalities or 1000 injured. The human consequences of technological accidents that do occur pale in significance to the consequences of natural disasters. (Quarantelli 1992). Research carried out at the Center for Risk Management, a specialist group within the Washington-based Resources for the Future. noted that natural disasters causing 25 or more deaths occur four times more frequently that major industrial accidents causing 5 or more deaths. Natural disasters also took over 150 times as many lives each year and claimed over 30 times as many lives per event. (Glickman, Golding and Silverman 1992).

However, such research does not reflect the long term environmental impact of chemical releases. Whereas natural disasters tend to cause immediate damage, pollution-related incidents can take years for the damage to be recognized and the effects can last generations. It is therefore important, not just for the environment *per se*, but for the well-being of future generations that we tackle accidents involving hazardous substances. Even though more pollution is caused by routine discharge of chemicals into the environment, accidents can and have caused serious effects in the past and will certainly continue to do so in the future. Technological or chemical disasters have a potential for increasing markedly because of the greater number of facilities producing and using hazardous materials, the increasing numbers of hazardous materials on the marketplace and the increasing growth in populations. (Showalter and Myers 1992).

2.2 Emergency Response in Developed Countries

In order to place the lessons from developing countries in context, it is useful to appreciate the approach to response in developed countries. This brief summary is intended to provide a flavour of some of the approaches and problems that could then be applied to the developing country scenario.

The Model

Risk

In developed countries the risk of an emergency or disaster can be lowered, but at a cost to society and individuals. The crucial decision determining whether the price is paid is the relationship of probability and consequence, seen in the context of ability to pay. There are many high frequency emergencies with limited societal consequence such as a traffic accident and relatively few low frequency but high consequence emergencies such as a Bhopal-type event. The societal willingness to pay for lowering the risk of a disaster is such that people in developed countries are prepared to accept a higher price for prevention and preparedness compared with the traffic accident. Being prepared to pay a higher price to feel safe from an accident is therefore important. (Norberg 1992). However, it must be recognized that such a model assumes people are in a position to pay for such risk reduction. It could be argued that such a luxury rarely exists among the majority of the developing world population and consequently the decisions about risk and reduction are often outside their influence.

Emergency Management Cycle

The classic approach is to see emergency and disaster management as a cycle: Prevention, Preparedness, Response, Recovery. The lessons from each are then incorporated back into the loop to improve the prevention, preparedness, response and recovery abilities for future use.

Planning is an important tool throughout the emergency management cycle. The time to invest money and resources in preparation is during what has been termed the "quiescent period" before the disaster strikes. Investing and preparing for possible disasters is much more cost effective than the price paid for search and rescue, medical care and recovery. (Silverstein 1992). Planning takes the form of risk assessment of industrial plants so that possible trends and likely scenarios can be identified and incorporated into the contingency plan. The plan itself depends on several integrated systems:

- knowledge of risks and hazards that are likely to be faced. This requires an assessment of the chemical industry in the area so that likely types of incidents can be identified and specific response plans drawn up. The use of past accident data and learning from previous responses is also an important element to any contingency plan. This in turn requires a means to report and analyze accidents thereby providing the basic building blocks for a strategy.
- an assessment of the capability to respond through regular and realistic simulation exercises. An emergency is not the time to see if the paper plan is workable.
- the establishment of a crisis management team to co-ordinate and command the needs of responders, communications, and assess if outside assistance is required.
- any plan must be sufficiently flexible to respond to changing circumstances. There is a danger in placing too much faith in a paper plan that doesn't fit some unforeseen circumstances. Therefore emergency managers must be sufficiently creative to respond to changing scenarios.

Tactics and Resources

Under the broad scale strategic management plan, tactical plans and plant contingency plans place the local circumstances into context. (Marshall 1992). Such tactical plans at the local level require technical decision-making ability at a lower level, usually at the level of the first responder, in most instances the firefighters who tend to be the first called.

But having an excellent paper plan is of little value if the responders, at the tactical and strategic level, have inadequate training and resources to accomplish their task. In developed countries specialist HazMat Response teams exist with full training provided in the technical complexity of handling a chemical spill. Their training varies from country to country. In North America, four levels of training in chemical response are used:

- First Responder Awareness - should be able to recognize hazards, secure an area and call for help
- First Responder Operational - responds to an incident and contains the spill
- Hazardous Materials Technician- -controls all aspects of operations at the site
- Incident Commander - manages the emergency response (Hosty 1993).

Training for the HazMat Technician varies among jurisdictions from 24 - 80 hours of training. Whilst a simple time limit for training is no measure of competence, it is important to note that such professionals will be trained in the recognition of chemical hazards, including use of specialized analysis and monitoring equipment , operational response to a variety of hazards using specialized equipment, decontamination and the scientific principles of hazardous material behaviour. Such teams are therefore trained to deal with whatever hazardous material emergencies occur in their area.

To back up the level of expertise the HazMat teams have access to specialized equipment to identify the chemicals involved, model the potential impacts of the spill (such as movement of airborne gases), contain and neutralize the chemical and decontaminate the site. Personal protection is paramount and each team is fully equipped with complete protection relevant to the nature of the problem faced.

This combination of planning, training and equipment provides the basis for suitable response to chemical emergencies in developed countries. From reports of different HazMat teams, an indication of the frequency of chemical incidents for which their specialized skills are required can be assessed. For example, in Sweden, with only 8.5 million inhabitants, the rescue services are called to some 1500 chemical accidents per year. (Norberg 1992).

Throughout OECD countries a voluntary accident notification scheme operates by which countries can place records of accidents onto a database coordinated by the France through BARPI. The aim is to allow accidents to be compared through standard reporting procedures and identify lessons that can then be incorporated as feedback into the emergency management cycle. In Sweden post-disaster analysis is an important element of the overall planning process. A special organization, KAMEDO, sends experts to the site of the accident within hours to collect information. The observers then write the reports on the accident and the conclusions which can be drawn. Medical and ambulance services are evaluated along with any problems of rescue services, police and communication and coordination. The reports are published by the National Board of Health and Welfare and used for feedback purposes. (Norberg 1992).

Impact monitoring

There are many links between the implications for health and environment impact of a chemical accident. It makes sense to combine the monitoring programme so that the broad effects can be established. Obviously in some circumstances health will be impacted but with relatively little environmental impact and vice versa. However, that impact would not be fully known until an adequate assessment has been carried out. For this purposes the techniques of medical assessment can be transposed to the environmental context. For instance, the prime requirement in both is to identify the substance as soon as possible and make the links with potential impact. Baxter identifies four steps:

- Hazard identification
- Exposure assessment
- Dose Response assessment
- Risk Characterization

- Hazard identification is the process whereby the source and type of release is confirmed. The plant or warehouse is checked to determine the chemical inventory and data banks interrogated to identify environmental and health hazard. Initial monitoring of the site and surrounding area should begin to assemble basic information on impact extent.
- Exposure assessment involves defining the extent of both human and ecosystem exposure. Detailed monitoring of air, water and soil should be undertaken. Indications of damage to vegetation and wildlife can be symptomatic of potential impact on humans. Dispersion modeling allows an assessment of likely movement of the spill and will provide an indication of areas likely to be affected so that proactive steps can be taken. e.g. evacuation, building of a containment berm, spread of booms etc.
- Dose response assessment requires the determination of the relation between level of exposure and the risk of health or environmental effects. In health terms this would see the start of an epidemiological assessment. In environmental terms detailed monitoring would be required.
- Risk characterization describes the risk, including any uncertainties that inevitably surround the prediction of likely long term effects. Experimental toxicology may be required to reduce the level of uncertainties and obviously can be a significantly time consuming process. However, for many chemicals such an approach is likely to be required if the long term implications are to be adequately described. (Baxter 1992).

To meet the need of environmental and health impact assessment Baxter suggests that *a pre-planned team will be needed to collect all the clinical, pathological, epidemiological, biochemical and environmental data necessary for making a risk assessment...Opportunities for data gathering are not going to be repeated and mistakes in this critical period will not be forgiven subsequently by an alienated community or exasperated politicians...A review of major chemical disasters has shown how the emergency responses can be faulted by the failure to adequately characterize the hazard and the human health risks with the result that the medical management had been delayed or ineffective. The team of experts would need to be established on a national basis to be available as back-up to local emergency officials who may lack the resources or expertise for this task. The incorporation of this thinking into national and local disaster planning is long overdue.* (Baxter 1992).

The Reality

Through the combination of planning, training, equipment and information most chemical emergencies are handled with relative ease in the developed world. However, emergencies often develop into crisis when things go wrong. It is not necessarily the biggest leak that causes the most problems; the definition of severity in an emergency depends very much on the circumstances on the ground both in terms of the incident itself, but also in terms of the ability of the responders to control the situation. Therefore what might be seen as a routine spill in a developed country is almost certain to be seen as a major incident in a country with less resources or experience.

Slipping into crisis

Even in the developed world, researchers have noted the problems of responding to a difficult incident where the emergency slips into crisis. Lagadec described the problems associated with many developed countries response capabilities: *Our tactical weapons are insufficient, our organizational structures too narrow, our business cultures fundamentally unadapted to dealing with the unforeseen, our fears camouflaged by rationalizations that crumble under the slightest pressure. We are poorly equipped to nip a crisis in the bud.* (Lagadec 1990). This assessment is based on the analysis of many technological crises from many sources such as PCB contamination in France, the Seveso dioxin crisis, the Amoco Cadiz spill, Schweizerhalle and the pollution of the

Rhine -all incidents where the control slipped away and the response managers were left floundering. Some of the problems identified include: a rigid reliance on inadequate and untested plans, the lack of sufficient information on detailed health and environmental risks, a failure to handle public relations during the crisis and the failure to incorporate feedback so that lessons are not learned. For example, at the Schweizerhalle fire in Switzerland in 1986 the firefighters responded well to the fire and used the established contingency plan to control the chemical blaze. However, nobody identified the real crisis, the spilling of chemical contaminated fire fighting water into the Rhine. When the severe environmental pollution was discovered later, the established early warning system between the countries bordering the Rhine failed and the media attacked the credibility of the chemical industry in general and the Swiss company in a particular, creating a severe crisis of confidence between the public and the industry. (Lagadec 1990).

Information

When the responders do arrive at site they need detailed information about the nature of the chemical involved and the best way to handle it. Many first response services are available by handbooks, computer programmes such as CAMEO and all backed up with specialist advice such as the US Chemtrec service which provides a 24 hour switchboard service that can provide immediate response information. However, while the response information might be available, there is a shortage of detailed medical and environmental toxicological information. Some 11 million chemicals have now been documented (Richardson 1993) and tens of thousands are in regular commercial use. Unfortunately adequate toxicological assessment is available for only a very small proportion. For example, when Bhopal occured, very little was known about the chemical released. (Weir 1986). As Baxter notes *it is naive to suppose that in most future emergencies all the necessary information is likely to be available in poison centres or industry data banks*. (Baxter 1992). Therefore there is a lot more that needs to be known about chemicals and their effects.

Other problems with information provision include the quality of "expert" advice. As Lagadec (1993) notes *Common sense on this point is generally deceptive, as it takes two angles: first, it is important to obtain a good diagnosis from the experts and , second, it is impossible to get two specialists to agree with each other.* This aspect of credibility of advice is important. Any information given must be able to be trusted; this gives a problem of knowing who to contact, the amount of trust that should be placed in them, and whether somebody else could give better information. These are all more pertinent at the corporate rather than the national level within developed countries but with developing countries knowing who to contact and how much they can trust them is an important consideration.

Decision making

Making decisions under emergency conditions will be fogged by stress and the need for urgency; this is where training and experience makes an enormous difference so that the responders know almost instinctively how an incident should be tackled. However, when the emergency starts to slip into crisis then decision-making becomes even more difficult. The problem of making "fateful decisions" was first recorded by the Chinese philosopher Sun Tzu: *Yang Chu, weeping at the crossroads, said "Isn't it here that you take a half step wrong and wake up a thousand miles astray?"*. (quoted in Lagadec 1993). More information on crisis management and managerial responses to decision making can be found in Lagadec 1993.

Lessons not learned

Another problem has been identified with regard to the quality of accident information collected in the aftermath of accidents. Despite statutory notification being in force in OECD countries, the quality of the data provided is variable. An OECD Expert Group on Chemical Accidents highlighted that of 214 voluntarily notified accidents, 149 reports suffered from either missing or imprecise information on effects and consequences of the emergencies. while 177 cases contained inadequate information about actions taken to prevent a recurrence. (OECD 1992). Such a lack of information makes assessment of impact difficult, if not impossible, and an opportunity to learn for the future has been wasted. The French Department for the Prevention of Pollution and Disasters are reported as having criticized existing national reporting systems as being insufficient. In 1989 705 serious industrial accidents were recorded but the Secretary of State for the Environment was quoted in the Press as saying *"If you consider statistics from other countries, with 10,000 industrial accidents in Canada and 23,000 accidental water pollution events in the UK, the French total must be several thousand a year"*. (International Environment Reporter 1990).

Two conclusions have been made by Lagadec: *First, no matter what efforts are made in the area of prevention, the possibility of grave events persist; second, the processes that are unfailingly set in motion immediately after an acute breakdown are generally very poorly handled. From a breakdown, we regularly find ourselves slipping rapidly out of control and into crisis - which means, roughly speaking, a situation in which any corrective efforts made are hampered by a sense of confusion, helplessness, and aggravation.* (Lagadec 1990).

From bad to worse

However, if the situation in the developed countries is far from ideal, the position in the developing countries is likely to be a long way behind. If routine emergencies occasionally slip into crisis or disaster even when the best equipment, training and planning has been made available it is easy to comprehend the enormity of any chemical problem facing a responder with no equipment, no training and no planning. If such responders cannot cope with relatively simple chemical incidents then there is no point trying to use them to tackle a major disaster because every chemical incident will be a disaster.

2.3 The social context of chemical emergencies in developing countries

Developing countries face increasing social pressures which will adversely affect the societies ability to respond to disasters. The increasing populations of many developing countries is matched by increasing urbanization. Of future population growth, 96% is expected to occur in developing countries and by 2010 there are expected to be 511 metropolises exceeding a million inhabitants. Predictions estimate that by 2000 77% of the population of Latin America, 41% of Africa and 35% of Asia will be urban.(UNPF 1991). The increase in poor housing and sanitary conditions and reliance on open water for drinking means that any technological disaster will certainly have a pronounced impact on such populations. The tendency for building industrial complexes close to urban areas, compounded by slums growing out and encapsulating industrial sites means that there will be increasing numbers of people living in close proximity to increasing amounts of chemical infrastructure. In any response activity the planning will become increasingly complex in terms of limiting damage, containing spills and organizing the evacuation of the population. As Quarantelli (1992) notes, *any disaster, technological or otherwise, will be worse in cities in developing societies than elsewhere, because they will impact localities already burdened by numerous everyday problems.*

It is likely that *people facing such conditions will not place great emphasis on low probability albeit high impact accidents. This is likely to be true of both individuals and officials. Researchers suggest that people who are already barely eking out an existence will not avoid a risky flood plain or the shadow of a volcano any more than they will eschew the squatter settlements around a pesticide factory in Bhopal or a liquefied gas facility in Mexico City. In short, the poorest of the poor are probably likely to reside in the path of both natural and technological hazards. (Bowonder and Kasperson 1988).*

As well as the social conditions leading to increased vulnerability to disaster, countries in the early stages of industrialization usually experience increased frequency of accident for several reasons:

- The weaker regulatory regime
- The condition of the infrastructure
- The limited availability of highly skilled engineers to service and maintain equipment. this results in dependence on the supplier, not only for technical know-how but also for service and replacement parts. Obtaining the latter involves delays, resulting in continued operation with worn or damaged components.
- The level of operator training, initially high because of vendor training, deteriorates with time because of personnel turnover. (WHO 1992).

Therefore, developing countries face increasing levels of accidents because of industrialization policy and those accidents will have greater impacts compared with developed countries. This social aspect of technological disaster is important to bear in mind, even when dealing with "environmental emergencies" because any response improvement, whether environmental or health, will have to operate within this social framework. For example, if governments have to choose between feeding their people under the threat of chemical accidents or reducing industrialization to limit risk, it is likely under current economic policy that industrialization will win every time. Therefore, although prevention and preparedness policies are vital components of any emergency planning, it must recognize that for many countries the resources don't exist to implement such policies effectively and that response organizations will bear the brunt of such socially-complicated scenarios. Some of the mistakes and difficulties imposed by the social conditions can be recognized from lessons identified in the Bhopal disaster.

2.4 Case study of the classic chemical disaster - Bhopal, India December 3 1984

The classic chemical disaster was Bhopal; although it cannot be seen as an environmental disaster as such because the impact was almost exclusively humanitarian. During the escape of toxic gas thousands died, many thousands more seriously wounded and the global chemical industry reeled from media attacks. However, although not an environmental disaster, it has been extensively studied and the lessons are applicable to all disasters, irrespective of the eventual primary impact. By examining such well studied disasters, the processes and development of emergency into crisis and ultimately disaster can be analyzed and applied to other scenarios to improve prevention and preparation.

Some researchers have broken down the disaster cycle into four phases; a quiescent phase, pro modal phase, the moment of cataclysm and a long recovery phase which leads to the beginning of another quiscent phase. (Silverstein 1992).

Quiescent phase The *Cascade of Errors* ,as Silverstein describes the series of events, begins with inadequate planning, poor site selection and slipshod construction. In the case of Bhopal the Union Carbide plant was sited needlessly close to the town and a slum area allowed to expand very near to the site. Very few people, including the Police Chief, knew of the dangers of the gas being produced. During the initial phases of a new plant there is a tendency to start off with well educated managers and trained technical personnel. Over time the level of training fell across the range of staff. Low worker morale was recorded. The facility has been described as being strategically unimportant and therefore did not receive adequate managerial attention and resources from the parent company. Warning about the safety of the plant were made by the local newspaper but disregarded as being alarmist and sensationalist. In May 1982 a Union Carbide safety team had investigated the plant and listed ten major deficiencies in safety procedures but although some of the recommendations to tighten up operations had been taken, by the time of the accident conditions had again deteriorated. (Silverstein 1992, ICFTU-ICEF 1985, Shrivastava 1987, 1987a).

The Pro dome - the early warning of disaster This often occurs when a minor variation from standard operating procedures is introduced. In Bhopal the production of the herbicide "Sevin" had been suspended for maintenance although the highly toxic ingredient Methyl Isocyanate (MIC) continued to be stored on site. This chemical becomes unstable over 5° C but the refrigeration system had been switched off the previous summer to save power. The exhaust scrubbers were shut down for maintenance and the required "empty" reserve tank into which material from a leaking tank could be transferred already contained MIC. The pro dome has been described by Silverstein as providing *a window of opportunity to end the cascade and abort full disaster. When scheduling a non-routine deviation from standard operation, all emergency systems should be checked and, where possible, the consequences of the deviate procedure should be evaluated in a computer model.* These steps were not taken. On the night of December 2, 1984, around 11pm. a supervisor asked an operator to wash pipes leading to the storage tanks. Because of faults in the system a large quantity of water entered the tank and shortly afterwards operators noted a buildup of pressure and temperature in the tank. Several attempts were made to remedy the situation but they all failed. This pro dome period allows an opportunity to warn the population about a possible disaster. As Silverstein noted; *it is a cruel error to withhold such information from potential victims because the warning is considered evidence of managerial failure. The excuse that the potentially affected citizenry will panic is an admission of failure to provide pre-disaster education. It is a form of disrespectful paternalism.* Other researchers have identified the cause of crisis such as this as the interaction of Human, Organizational and Technological factors to produce the triggering event which in turn combines with Regulatory, Infrastructural and Preparedness failures in the organizational environment. (Shrivastava, Mitroff, Miller and Miglani 1988).

The catastrophe Around 40 tonnes of MIC was released into the atmosphere in an uncontrolled emission at around 1am. Outside the plant the city was thrown into complete chaos and panic. no one knew of appropriate emergency procedures and the medical system did not have the resources to handle the emergency. Even today there is dispute over how many people were killed and injured.

The Recovery the disaster at Bhopal will continue to haunt the population, the chemical industry and governments for a long time. The world's worst chemical disaster directly led to the establishment of many national chemical emergency management organizations such as the US Environmental Protection Agency Chemical Emergency Preparedness and Prevention Office. Other aspects of the recovery phase was the conflict that developed between the affected population and both Union Carbide and the Indian Government. In a series of songs and poems written after the event the company was portrayed as a murderer and the government as the accomplice. Also the victims equated the interests of Union Carbide with the interests of the USA, its country of origin. (Shrivastava 1987b). The Indian Government were condemned for agreeing to very low levels of compensation of $470 million to be divided among the victims. Critics claimed this settlement represents a small fraction of the compensation that would be required in a developed country. Of an estimated 615,000 death and personal injury claims only 5,700 have been decided by the courts. Although the Indian Government said it agreed to the lower compensation figure to allow speedy processing of settlements, lawyers and officials have been quoted as saying it could take 20 years to resolve the compensation issue. (International Herald Tribune 1993).

Lessons

- The importance of integrated Prevention, Preparedness and Response planning is obvious. Prevention can reduce the number of emergencies that occur; Preparedness can help stop an emergency developing into a disaster; Response is required when these both fail. If Bhopal is indicative of the situation in other countries, response planning is vital to back-up unsafe industrial practices.
- There is a need for industry to voluntarily assure good safety and environmental practice wherever they operate in the world or for host governments to develop legislation is adequate to ensure good practice
- Although the environmental impact was very low compared with the humanitarian impact, such a breakdown of effect would not be known unless monitoring had taken place. Therefore every chemical incident must be treated as having environmental effects until proven otherwise.
- If such disasters occur as a result of negligence from either industry or government, it is not just the victims who are affected. Companies and governments lose a great deal of public confidence which have economic and political repercussions. Liability for industrial accidents is an extremely controversial but important element that will need to be addressed by the international community.

But as some commentators have noted, although a lot of general and specific lessons can be learned from this accident, what a terrible price was paid for these lessons. (Koplan, Falk and Green 1990).

Having used Bhopal to illustrate some of the broad pointers of disasters, it must be noted that unless the national response capability can cope with smaller emergencies there is no hope that they could conceivably tackle disasters. Therefore it is arguably more important to examine how countries respond to major emergencies rather than disasters alone. This has been the approach of this report.