Review Paper

Environmental Management- strategies for chemical disaster

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Introduction

The rapid growth in the use of hazardous chemicals in industry and trade has brought about a very significant increase in the number of people and whose life could be endangered at any time by an accident involving these chemicals. The rapid pace of progress in modern technology allows less opportunity for learning by trial and error, making it increasingly necessary to set design and operating procedures. Public concern at multiple injuries and deaths from spectacular events such as a major explosion invariably leads to calls for additional controls at national and international levels. In recent years, much effort has been devoted to the development of legislation controlling major hazards.

The growth of chemical industries has led to an increase in the risk of occurrence of accidents associated with hazardous chemicals. A chemical industry that incorporates the best principal of safety can prevent such accidents. Common causes for chemical for chemical accidents are deficiencies in safety management systems and human errors, or they may occur as a consequence of natural calamities or sabotage activities. Chemical accidents result in fire, explosion and/or toxic release. The nature of chemical agents and their concentration during exposure ultimately decides the toxicity and damaging effects on living organism in the form and signs like irreversible pain, suffering, and death. Metrological conditions such as wind speed, wind direction height of inversion layer, stability class etc. also pay an important role by affecting the dispersion pattern of toxic gas clouds. The Bhopal Gas tragedy of 1984- the worst chemical disaster in history, where over 2000 people died due to accidental release of toxic gas Methyl Isocyanate, is still fresh in our memories. Such accidents are significant in terms of injuries, pain, suffering, loss of lives and damage of property environment. A small accident occurring at the local level may be a prior warning signal for impending and disaster. Chemical disaster, through low in frequency, has the potential to cause significant immediate or long term damage.

Large quantities of chemicals are also stored/ possessed in industries that are located in densely populated areas- inappropriate and haphazard construction and lack of awareness and preparedness on the part of the community further enhance their vulnerability. The potential of toxic releases and adverse consequences on the environment due to a chemical accident calls for further improvement of safety measure in all processes /procedures and adoption of appropriate methods for handling hazardous chemicals.

Sources of Chemical Disaster

Chemical accidents may originate in:

- Manufacturing and formulation installations including during commissioning and process operations; maintenance and disposal
- Material handling and storage in manufacturing facilities, and isolated storages; warehouses and go downs including tank farms in ports and docks and fuel depots
- Transportation (road, rail, air, water and pipelines)

Causative factors leading to chemical disasters: Major accident can be caused by flammable and toxic substances, if the storage and handling is not proper. Accidents due to fire and explosion by flammable substances are more common in process industries than toxic release.

Fire, Explosion, Toxic release, Poisoning, Combinations of the above,

Impact of chemical disasters: In addition to loss of life, the major consequences of chemical disasters include impact on livestock, flora/fauna, the environment (air, soil, water) and losses to industry as shown in Figure 1.Chemical accidents may be categorised as a major accident or a disaster depending upon the number of casualties, injuries, damage to the property or environment.

Storage and handling: In chemical industries, storage and use of bulk quantities of highly flammable and toxic substances are often inevitable, but always poses a threat to the employees inside the industry, as well as to the neighbouring community and environment. Investigations have revealed that a great majority of the accidents occurred in the storage installations, as a result of inappropriate design, poor maintenance or faulty operation of the plant. Chemical in any form can be safely stored, handled and used if their physical, chemical and hazardous properties are fully understood and the necessary safety precautions are taken.

Safety in the storage of hazardous chemicals:

- Compatibility and segregation of stored chemicals
- Properties and quantity of chemicals to be stored
- Security and sitting of and access of stores
- Construction, nature and integrity of storage containers
- Loading and unloading of storage containers
- Labelling and re- labelling requirements
- Precautions against accidental release, fire, explosion and chemical reactivity
- Temperature, humidity and ventilation
- Precautions and procedures in case of spillage
- Emergency procedures
- Possible physical and chemical changes in stored chemicals

Process and operations: The chemical industry produces a processes and products which sometimes involve extremes conditions of temperatures, pressure, hazardous operations or use of toxic chemicals. Major change lead in turn to a series of minor changes as knowledge increase and processes are optimized. Thus there is need to develop within the industry, growing awareness of the systematic approaches to safety particularly in plant design.

The need to check the design for errors and emissions has been recognized for a long time, but this has traditionally been done on an individual basis. Experts have usually applied their special skills or experience to check the particular aspects of design. The examination of procedure takes a full description of the process, systematically questions every part and of it to discover how deviations from the intension of the design can occur and decides whether these deviations can give rises to hazards. It has become increasingly clear in recent years that although codes of practice are extremely valuable, it is particularly important to supplement them with an imaginative anticipation of hazards when new projects involve new technology.

The applications of a formal systematic critical examination to the process and engineering intensions of the new facilities to assess the hazard potential of most operations as malfunctions of individual items of equipments and the consequential effects on the facility as a whole is essential to ensure chemical safety.

Brief Accident Histories

Numerous major chemical accidents happened over the last several years. Most of these accidents involved fatalities, and had some significant impact on people in nearby residential communities. All involved worker injuries and substantial on-site property damage. The following list includes some of the more notable among these table 1 and 2.

Common Factors

These accidents involved different events, varying circumstances, and a unique set of consequences. These include the following:

- Inadequate hazard review or process hazards analysis
- Installation of pollution control equipment
- Use of inappropriate or poorly designed equipment

- Inadequate indications of process condition
- Warnings went unheeded

Primitive Measures

- No forest land shall be converted in to non forest activity for the sustenance of the industry (Forest conservation act, 1980)
- No prime agricultural land shall be converted into an industrial site
- Within the acquired site the industry must locate itself at the lowest location to remain obscured from general sight
- Land acquired shall be sufficiently large enough to provide space for appropriate treatment of wastewater after maximum possible reuse and recycling
- The green belt between adjoining large scale plants shall be 1 km.
- Enough space should be provided for storage of solid wastes so that these could be available for possible reuse
- Lay out and form of the industry that may come up in the area must conform to the landscape of the area without affecting the scenic features of that place
- Associated township of the industry must be created at a place having a physicographic barrier between the industry and township
- Each industry is required to maintain three ambient air quality measuring station at a 120 C angle between stations

Environmental Guidelines

The following environmental guidelines are recommended for sitting of industries to ensure optimum use of natural and manmade resources in sustainable manner with

- Minimal depletion
- Degradation
- Destruction of the environment

The following distances from industrial sites should be taken into account.

- Ecological and/ or otherwise sensitive areas-At least 25 km away, depend on the geo-climatic conditions. The requisite distance shall have to be increased by appropriate agency.
- Coastal Areas- At least ½ km from high tide line
- Floodplain of the Riverine Systems- At least ½ km from floodplains or modified floodplains, affected by dams in the upstream or by flood control systems.
- Transport / Communication system- At least ½ km from the high way lines and railway station

Major settlements

- Distance from settlements is difficult to maintain because of urban sprawl
- At the time of sitting of the industry if any major settlements are noted within 50 km the spatial direction of growth of the settlement must be assessed
- The industry shall be sited at least 25 km from the projected growth boundary of the settlement

Environmental impact assessment

- Metrology and air quality
- Hydrology and water quality
- Sites and its surrounding
- Occupational safety and health
- Details of the treatment and disposal of effluents and the methods of alternative uses
- Transportation of raw material and details of material handling
- Impact on sensitive targets
- Control equipment and measures proposed to be adopted

Strengthening of the present regulatory framework; augmentation of technical support function

- A supportive and technology neutral regulation framework
- Legislation on land-use policy
- Standardization of national codes and practices
- Emphasis on regular safely audit
- Commissioning and decommissioning of chemical industries
- Preparation of on -site and off site plans
- Regular testing of emergency plans
- Need of medical first responders and medical inventory
- Crises management plans of hospitals
- Concept of mobile hospital and mobile teams

- Issues related to public health responses, medical rehabilitation and harmful effects on the environment
- Post disaster documentation and analysis

Implementing relevant statues on management of chemical substances

- The Environment (Protection) Act, 1986 (amended 1991) and following Rules there under:
  - The Environment (Protection) Rules, 1986 (amended 2004).
  - The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 (amended 1994 and 2000).
  - The Hazardous Wastes (Management and Handling) Rules, 1989 (amended 2000 and 2003).
  - The Environment Impact Assessment Notification, 2006
  - The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996
  - Bio-medical Wastes (Management and Handling) Rules, 1989.

- The Factories Act, 1948 (amended 1987): State Factory Rules.
- The Inflammable Substances Act, 1952
- The Motor Vehicles Act, 1988 (amended 2001): The Central Motor Vehicles Rules, 1989 (amended 2005)
- The Public Liability Insurance Act, 1991 (amended 1992): The Public Liability Insurance Rules, 1991 (amended 1991)
- The Petroleum Act, 1934: The Petroleum Rules, 2002
- The Insecticide Act, 1968 (amended, 2000): The Insecticide Rules 1971 (amended 1999)
- The National Environment Tribunal Act, 1995
- The Explosive Act, 1884 (amended till 1983): The Gas Cylinder Rules, 2004. The Static and Mobile Pressure Vessels (Unfired) Rules, 1981 (amended 2002). The Explosives Rules, 1983 (amended 2002).

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9. The Environmental Protection Act, **(1986)**

10. The Factories (Amendment) Act, **(1987)**

11. The Forest Conservation Act, **(1980)**

Table-1: Major chemical accidents- International scenario

Source: Ministry of Environment and Forests, Government of India, New Delhi, Manual on Emergency Preparedness for Chemical Hazards, 1992

S. No.	Name of Unit	Date of Accident	Source	Death/Injury/ Missing; losses
1	Terra Industries, Inc., Port Neal, Iowa	December 13, 1994	explosion of an ammonium nitrate unit	4/18
2	Powell Duffryn Terminals, Inc. (PDTI), Savannah, Georgia	April 10, 1995	crude □luminiu turpentine fire and hydrogen □luminiu release	5/2000 residents were evacuated for up to 30 days,
3	NAPP Technologies, Lodi, New Jersey	April 21, 1995	mixture of sodium hydrosulfite, Aluminium powder, potassium carbonate and benzaldehyde exploded, triggering a major fire	4/numerous
4	Pennzoil Product Company Refinery, Rouseville, PA	October 16, 1995	an explosion and fire erupted in storage tanks containing flammable hydrocarbons and wastewater	3/3
5	Tosco Company Refinery, Martinez, CA	January 21, 1997	a major fire started at a hydrocracker unit when a temperature excursion occurred, causing a piping elbow to fail catastrophically	1/44
6	Surpass Chemical Company, Albany, NY	April 8, 1997	a storage tank failed causing a large spill of hydrochloric acid (HCl).	43/
7	Shell Chemical Company, Deer Park, TX,	June 22, 1997	a large explosion and fire occurred in an olefins production unit	1/several
8	Georgia Pacific, Columbus, Ohio,	September 10, 1997	an explosion occurred in the phenol/formaldehyde reaction kettle of a resin manufacturing process	1/13

Table-2: Some major chemical accidents in India

S. No.	Name of Unit	Date of Accident	Source	Death/Injury/ Missing; losses
1.	GACL, Vadodara, Gujarat	September 05, 2002	Chlorine gas explosion	4/20/nil
2.	IPCL, Gandhar, Gujarat,	December, 20,2002	Chlorine gas release	Nil/8 workers/ 300 villagers in Jageshwer affected
3.	IOC Refineries, Digboi, Assam	March, 07, 2003	Fire in Motor spirit tank	Nil/ Product loss Rs 11.55 crore
4.	Ranbaxy Laboratories Ltd Mohali, Punjab	Jube, 11, 2003	Toluene	2/9/nil
5.	BPCL Bottling Plant, Dhar, Madhya Pradesh	October, 05, 2003	LPG leak from Tank Lorry	Nil
6.	Orient Paper mills, Amla Madhya Pradesh	October, 13, 2003	Liquid Chlorine	Nil/88/nil; 5 m pipe affected
7.	. IDL Gulf Oil, Kukkatpally Hyderabad, Andhra Pradesh	November, 25, 2003	Explosion	8/15
8.	Anil Enterprises, Zakhira Rohtak, Haryana	28.04.2004	Fire in LPG fired oven	6/2.nil
9	HIL Udyogmandal, Kerala	06.07.2004	Toluene fire	nil
10	Shyamlal Industries, GIDC Vatva, Ahmedabad,Gujarat	12.04.2004	Benzene fire	nil
11	Chemical Factory, Dombivilli Maharashtra	31.05.2004	Hexane release fire	1/8/Nil
12.	. Chemplast, Mettur, Tamil Nadu	18.07.2004	Chlorine leak	Nil/27/nil
13	Gujarat Refinery, Vadodara	29.10.2004	Explosion in slurry settler	2/13/nil
14	Ranbaxy Laboratories Ltd Mohali, Punjab	30.10.2004	Fire in dryer room	1/2/nil
15	Matrix Laboratory Ltd. Unit 1 Kazipally, Medak District Andhra Pradesh	05.03.2005	Sodium hydride	8/nil/nil
16	. Gujarat Refinery, Gujarat Ennore, Tamil Nadu	15.06.2005	Fire	Nil
17	Coromondal Fertilizer Ltd., Ennore, Tamil Nadu	22.07.2005	Ammonia	Nil/5/nil
18	Gulf Oil Corporation Ltd Sanathnagarn, Hyderabad, Andhra Pradesh	04.10.2005	Explosion/fire	2/2/nil
19	Orchid Chemicals and Pharmaceuticals Ltd Alathur, Kancheepuram District, Tamil Nadu	03.11.2005	Explosion	2/4/nil
20	Aurobindo Pharma Ltd Unit-V, IDA Pashamylaram Medak Dist., Andhra Pradesh	28.11.2005	Explosion while drying cloxaciline	1/4/nil
21	Indian Oil Corporation Ltd., Mathura Refinery, Mathura, UP	29.12.2005	Fire	1/nil/nil

22	Kanoria Chemicals and Industries Ltd. Renukoot Sonebhadra, Uttar Pradesh	29.03.2006	Chlorine release	6/23/nil
23	Anjana Explosives Ltd Peddakaparthi Nalgonda District, Andhra Pradesh	., 18.07.2006	Spillage of hazchem	5/nil/nil
24	Ravi Organics Ltd Muzzaffarnagar, Uttar Pradesh	19.09.2006	Gas release	1/nil/nil
25	Reliance Industries Refinery Jamnagar, Gujarat	25.10.2006	Leaked hot vaccum gas oil catches fire in air	2/nil/nil

Source: National Disaster Management Authority, Government of India, National Disaster Management Guidelines Chemical Disasters, 2007.

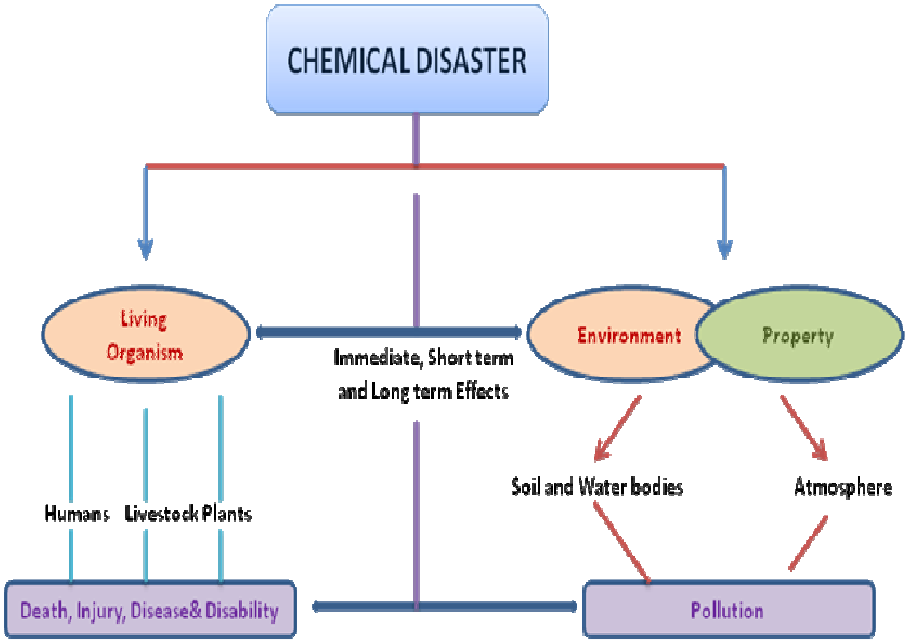

Figure-1: Consequences of a Chemical Disaster