

The Risk and Vulnerability Associated with Natech Disasters: A Study on Future Need of Risk Assessment in Context to Indian sub-continent

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ABSTRACT: Jeopardy of damage always prevails with natural disasters, but when the natural disaster combines with technological aspects, the failure may result as a potential cause for mass destruction. The disaster risk reduction measures taken by responders may not be sufficient as the usual practice is to face individual disaster at a time is prominent. The secondary disaster that results due to primary disaster in case of Natechs is generally not considered as the focus point in on response mechanism of sudden disaster like tsunami or earthquake. This paper highlights the need to assess the outcomes of hazards & associated risks due Natechs in South East Asian countries like India that are highly populated and the effect of devastation of Natechs can go beyond imagination.

KEYWORDS: Natural and Technological Disasters; Natechs; Risk Assessment; Industrial accidents; Secondary & Primary Disaster

I. INTRODUCTION

Natural disaster not only creates a primary vulnerable condition but also contributes in initiating effects of secondary disaster which further can become a root cause of hazards like fire, explosion, toxic release, chemical spillage etc. A very common example is the effect of earthquake on industrial any chemical or heavy industrial unit. Even a small shake of earth may increase the vulnerability of people nearby to a very large extent. The spectrum of industries in sub-continent is very dense and if a slight incident occurs the subsequent effect will be devastating. The initiation of secondary disaster due to technological failure that may arise as a result of primary disaster is termed as "Natechs". Usually all the industries follow proper rules and regulation and prepare an onsite plan for facing any kind of disaster within their premises. When any emergency situation arises that goes beyond the capacity of industry then district administration has to take control of such kind of situation. Natechs creates new challenges for disaster risk reduction as the solution to face primary disaster is very much different in comparison to technological disaster.

^[1]Hicyilmaz at 15 WCEE has described in Seismic Retrofitting Journey of Industrial Buildings wherein he laid emphasis on the increasing trend of pharmaceutical sector in Baddi, Himachal Pradesh which lies in seismic zone factor of IV (i.e. 0.24g) as per Indian seismic code, IS 1893. Baddi Municipal Council has population of 29,911 as per report released by Census India 2011. There is around 270 pharmaceuticals units in Baddi which stores, manufacture and transport various hazardous materials so the effects of Natech disaster may be beyond imagination if earthquake as a primary disaster triggers chemical industrial secondary (technological) disaster. In this paper Natechs hazard and vulnerability risk assessment of sub-continent has been discussed. The paper also discusses the gap analysis of disastrous situation that may probably result as a consequence of Natech disasters.

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II. WHAT IS NATECH DISASTER?

The understanding of Natech disaster may be very well understood by analyzing manmade disaster like chemical leakage, toxic fumes, contamination due to chemicals in the environment, pollutions etc. which on their own is very dangerous to handle. The primary disasters like earthquake, tsunami, flood, cyclones etc. may anytime can trigger the man-made disasters. [2] Ana Maria Cruz has highlighted Natech risk management practices and risk reduction initiatives undertaken by individual countries, as well as gaps in current regulatory requirements which clearly indicates the preparedness level of developed countries like United States, the state of California, Turkey, Japan and several European countries. In a broader term Natech terminology is a technological accident triggered by a natural disaster, like earthquakes, floods, storms, lightning, landslides, etc. In this context Natech is understood as:

- Leakage of hazardous material through chemical plant and infrastructure damage.
- Leakage of hazardous materials from gas and oil pipelines.
- Toxic cloud formation and release of hazardous material in atmosphere.
- Blast of boiler or any other important units in chemical plant.
- Uncontrolled reaction which may turn into fire or boiling liquid expanding vapor explosion (BLEVE).

Natech disaster may be taken into keen consideration in today's changing era of globalization as secondary disaster may be triggered simultaneously at multiple locations. There are very limited resources to mitigate the effects of primary and secondary disaster together and at same time. Incident response system may not be activated as the usual practice of response is to cater one disaster and almost having the same nature at one time. The hazard mapping for Natech disaster is not available at each and every location where probable Natech disaster may occur. The mitigation strategies are not usually assessed for Natech disaster in almost entire sub-continent region. Figure 1 shows that any segment of disaster like earthquake, flood, tsunami etc. can result in Natech.

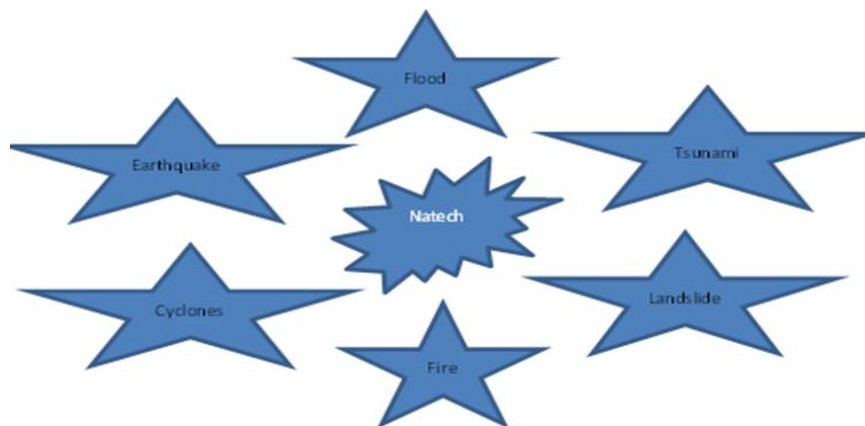


Figure 1: Natural Disaster triggering Natech

III. PROBABILISTIC RISK ASSESSMENT (PRA) FOR NATECH DISASTERS

Certain interrelations can be understood between natural disasters that trigger's the technological disaster. The overall mechanism can be very well be analyzed on the basis of [3] Probabilistic risk assessment (PRA) approach. Probabilistic risk assessment (PRA) is a systematic and comprehensive methodology to evaluate risks associated with a complex engineered technological entity (such as refinery or a chemical plant) or the effects of stressors on the environment. The risk associated with Natech up to some extent may be assessed by probabilistic risk assessment approach.

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Risk in a Natech PRA may be defined as a feasible detrimental outcome of a combined effect of natural and technological disaster. In a Natech PRA, risk is characterized by two quantities:

- Magnitude (severity) of the possible adverse consequence(s) of natural disasters along with triggering of technological disaster, and
- Likelihood (probability) of occurrence of each natural disaster (Eg. Earthquake, tsunami, cyclone etc.)

Sr No.	Natural Disaster	Technological Disaster	Natech Probabilistic Risk Assessment (PRA)	Total Risk
1	Earthquake	a) Shaking of Chemical Industrial unit b) Crack in industrial premises and pipelines	i. BLEVE (boiling liquid expanding vapor explosion) ii. Infrastructure collapse iii. Heavy Leakage of Gas	i. Life ii. Property iii. Economy
2	Tsunami	a) Smashing force of a wall of water traveling at high speed can break industries b) Destructive power of a large volume of water draining off the land and carrying all with it may dismantle industrial units	i. Objects and industrial building are destroyed by the sheer weight of the water ii. Large objects such as storage tank and boulders can be carried several miles inland before the tsunami subsides.	i. Life ii. Property iii. Environment iv. Economy
3	Flood	a) Inundation of an industrial area with water b) Rising floodwaters can displace and overturn chemical-storage tanks and rupture pipework and pipelines c) Flooding of internal plant drainage systems may release waste oil or other chemical waste	i. Release of hazardous materials ii. Damage to on-site emergency equipment iii. Damage to essential infrastructure iv. Displacement of storage tanks and rupturing of pipework v. Release of waste from chemical plants, mines and dams	i. Life ii. Property iii. Environment iv. Economy
4	Landslide	a) Buildings and infrastructure such as transportation facilities and pipelines in the path of a landslide can be damaged or destroyed b) Slope creep or small, early-stage landslide movements can cause substantial structural damage to critical facilities such as dams and pipelines	i. Leakage of hazardous or flammable gas ii. Fire iii. Essential structure rupture and collapse	i. Life ii. Economy iii. Power iv. Property
5	Cyclones	a) Extensive damage to industrial buildings b) Rupture of critical infrastructure facilities	i. Fire ii. Mixing of incompatible chemicals iii. Contamination of huge area due to leak of chemicals	i. Life ii. Economy iii. Power iv. Environment v. Property

Table 1: Probabilistic risk assessment (PRA) of Natech Disaster

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Vol. 7, Issue 7, July 2018

Table 1 shows the risk matrix of Probabilistic Risk Assessment (PRA) which shows the role of some common natural disaster in triggering technological disasters. The risk and vulnerability of Natech disaster depends upon the intensity of natural disaster. The risk to life, property, vegetation, environment, livestock etc. is more probable. The problem of Natech disaster that as the impact of natural increases simultaneously the influence of Natech also increases. For example in case of any cyclone incident any leakage from pipeline that has been broke down due to high wind can propagate up to miles depending upon the wind velocity. And hence the damage due to cyclone is very minimal in comparison to contamination of a big area.

IV. INDIAN INDUSTRIAL UNITS IN ZONES OF NATURAL DISASTER

India has witnessed the world’s worst chemical (industrial) disaster “Bhopal Gas Tragedy” in the year 1984. The Bhopal Gas tragedy was most devastating chemical accident in history, where over thousands of people died due to accidental release of toxic gas Methyl IsoCyanate (MIC). Such accidents are significant in terms of injuries, pain, suffering, loss of lives, damage to property and environment. India continued to witness a series of chemical accidents even after Bhopal had demonstrated the vulnerability of the country. Only in last decade, 130 significant chemical accidents reported in India, which resulted into 259 deaths and 563 number of major injured.

⁶There are about 1861 Major Accident Hazard (MAH) units, spread across 301 districts and 25 states & 3 Union Territories, in all zones of country. Besides, there are thousands of registered and hazardous factories (below MAH criteria) and un-organized sectors dealing with numerous range of hazardous material posing serious and complex levels of disaster risks. Although above mentioned chemical disaster of Bhopal was a consequence of manmade fault but the vulnerability of technological disaster is increasing day by day due to natural disasters.

Vulnerability of MAH units against natural disasters has been shown in Table 2. The common type of natural disasters like earthquake, flood, cyclone, tsunami etc are quiet active where major industrial hubs exists. The slight increase in intensity of any natural disaster in these vulnerable zones can dismantle any part of these industries. Even a small change in design of industrial unit can cause major damage to society as all the parameters like pressure, temperature has to maintain up to a certain limit for controlled processing. The natural disaster has the potential to trigger secondary disaster in no time as most o the industries some way or another falls in the zones of disaster risk.

SrNo	Natural Disaster	Major Affected Zones	Industrial areas/Major accidental hazard units in risk zones
1	Earthquake	⁴ Bureau of Indian Standards [IS 1893 (Part I):2002], has grouped the country into four seismic zones, viz. Zone II, III, IV and V. Of these, Zone V is seismically the most active region, while zone II is the least. Broadly, <ul style="list-style-type: none"> i. Zone - V comprises entire northeastern India, parts of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Rann of Kutch in Gujarat, part of North Bihar and Andaman & Nicobar Islands. 	⁵ Maharashtra - 322 (Zone IV) Gujarat -260 (Zone III &IV) Rajasthan -90 (Zone III &IV) Tamil Nadu - 86 (Zone III)

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 7, July 2018

		<p>ii. Zone - IV covers remaining parts of Jammu and Kashmir and Himachal Pradesh, National Capital Territory (NCT) of Delhi, Sikkim, Northern Parts of Uttar Pradesh, Bihar and West Bengal, parts of Gujarat and small portions of Maharashtra near the west coast and Rajasthan.</p> <p>iii. Zone - III comprises Kerala, Goa, Lakshadweep islands, remaining parts of Uttar Pradesh, Gujarat and West Bengal, Parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Orissa, Andhra Pradesh, Tamilnadu and Karnataka.</p> <p>iv. Zone - II covers remaining parts of country.</p>	<p>Andhra Pradesh -82 (Zone III &IV)</p> <p>Apart of these there are several states that falls in high risk earthquake zones.</p>
2	Tsunami	Coastal regions are prone to tsunami	<p>Andhar Pradesh – 82</p> <p>Tamil Nadu - 86</p> <p>Kerala -31</p>
3	Flood	Almost entire sub-continent is prone to moderate to heavy flood	MAH units in Gujarat, Maharashtra, Tamil Nadu, Uttar Pradesh etc.
4	Landslide	Mountain terrain is mostly vulnerable	Some industries of Uttarakhand ,Himachal Pradesh
5	Cyclones	Coastal regions are prone to tsunami	<p>Andhar Pradesh – 82</p> <p>Tamil Nadu - 86</p> <p>Kerala -31</p>

Table 2: Vulnerability of MAH units against natural disasters

The above table also elaborates the earthquake zones wherein these major accidental units lie. The zone may be less or more but even a minor change in fabrication of chemical industrial unit may cause potential and significant damage to complete environment leading to loss of life and property. The same implies in case of flood, tsunami, heavy wind or any type of natural disaster. The impact of natural disaster is devastating and if the result of natural disaster results in technological disaster the outcome will go beyond imagination.

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Vol. 7, Issue 7, July 2018

V. ALARMING STATUS QUO OF NATECH DISASTER AS PER INDIAN SCENARIO

Indian subcontinent is vulnerable to approx. all kind of natural disasters. Rapid urbanization & industrialization had increased migration of huge mass from villages to industrial areas. ⁷Population density (per sq. km) has rapidly increased throughout the nation. States like Gujarat (308), Maharashtra (365), Tamil Nadu (55), Andhra Pradesh (308), Uttar Pradesh (828) etc. had shown huge change in recent decade where most industrial zones exists. Apart of these states smaller states and UTs are also facing the same increase in population density.

Gujarat contributes at least 30 % of major accidental hazard units followed by Maharashtra; all these states are multi hazard prone states where the probability of occurrence of natural disaster always exists. The concern basically focus on Natech disaster risk as overall response mechanism in India focuses on a single disaster risk reduction approach and the authorities are not very well equipped if simultaneously two disaster outbreak. The approach of western countries should be replicated which had started searching of alternating mechanism to increase their coping capacity against technological disaster. The certain mechanisms that Indian subcontinent may incorporate in their existing DRR measures are as follows;

- 1) Strict implementation of Seveso II type of directive which states that industrial facilities that store, use or handle dangerous substances are required to set out a major-accident prevention policy, write and submit a safety report, and establish emergency plans in the case of an accidental chemical release ^[8].
- 2) The ⁹Risk Management Plan (RMP) rule under the Environmental Protection Agency (EPA) should be the used to update local District Disaster Management Plan
- 3) Adoption stringent seismic design codes, land usage planning ordinances, and building of preventive infrastructure near of major accidental hazardous units.
- 4) Report inventories of the storage, processing, and disposal of hazardous chemicals and flammable substances should be made available to district authorities.
- 5) Hazard Risk Vulnerability & Capacity (HRVC) analysis keeping in mind of possible Natech disaster resulting from natural disaster in entire country.
- 6) Incident Response System specifically for Natech or chemical industrial disasters should be practiced regularly and stringent monitoring must be ensured.

VI. CONCLUSION

The concept of Natech disaster is not a new one for country like India as the country had already witnessed a technical failure & Bhopal disaster .In the past decade rapid industrialization had taken care of all possible parameters of safety and most industrial area follows the rule s and regulation. Natech disaster is a result of manmade and natural disaster that can only me mitigate by preparedness in a timely manner. The overall scenario of Natech disaster can only be controlled by implementing and following strict rules in such a highly populated country .The authorities has to initiate certain mechanism to map Natech disaster risk and its mitigating strategies. The concern of natural disaster in more in India e.g. flood, drought, earthquake etc but the impact of Natech may be very rapid and uncontrollable. Early Natech disaster risk should be assessed by decision makers and preparedness part should commence as soon as possible.

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