International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 3 | Issue 3 | ISSN : 2456-3307

The Impact of Chemical Disaster Due to Leakage of Chemical at the SIIDCUL Industrial Area in Haridwar A predictive qualitative study with the help of Tools & Software's

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ABSTRACT

This paper seeks to analyze the impact of chemical industrial disaster events on hazard, risk, vulnerability & capacity (HRVC) assessment at the municipal level in SIIDCUL Industrial Area, Haridwar. We focus on the effect of such events on indicators such as the hazard and risk matrix along with vulnerability analysis for different levels. We control for a set of geographical and industrial chemical characteristics of location which may make more prone for occurrence of these events. We also control for a set of prerequisite institutional, fiscal and demographic characteristics to control for assortment. Using an adjusted difference-in-difference regression with data for 2000 and 2005, results show a significant decrease of vulnerability indicators for industrial events, and especially for industrial fire, explosion, and chemical leakage.

Keywords: Chemical Industrial disasters, Disaster Risk Reduction, Risk, Hazards, Vulnerability, Environment.

I. INTRODUCTION

Haridwar district is a district in the state of Uttarakhand, India. It is headquartered at Haridwar which is also its largest city. The district is ringed by the districts Dehradun in the north and east, Pauri Garhwal in the east and the Uttar Pradesh districts of Muzaffarnagar and Bijnor in the south and Saharanpur in the west. During last few years, after a wide growth of industrial sector in Haridwar, there has been an increase in the reports of industrial disasters.

Haridwar falls in Zone IV of the seismic risk map of India. Flood is also predominant in this region as the complete area lies in flood zone of river Ganga. Haridwar is experiencing an increment in number of natural disasters, but as a major growth of industries in this area, the increase of chemical industrial disaster is a new problem that Haridwar is facing day by day. The lives of people residing nearby the industrial units are continuously at a danger of exposure to risk of leakage and fire of industrial chemicals.

To explore these issues, this paper examines data from a database of industrial chemical disasters in Haridwar which register a series of industrial chemical disaster at the local level in the district and especially in SIIDCUL industrial region, and using data from other public sources, we aim to focus some light on the industrial chemical disasters literature of SIIDCUL industrial area Haridwar, while focusing on the local hazard, risk and vulnerability. Specifically, we will focus on how industrial chemical disasters may affect local population at the ground level, such as the exposure risk in case of chemical leakage and fire hazards due to industrial set up in SIIDCUL industrial area, between years 2000 and 2005. Using the chemical industrial disaster event as an unnatural event we use a divergent methodology to isolate the impact. In addition, as we are using a variety of

parameters to assess the impact of disaster, we control for the dissimilarity of them, and control for variables in man-made and geographical aspects, as well as for institutional and local capacity, fiscal, and some coping capacities for localities, to implement a divergent methodology to isolate the impact.

II. HOW INDUSTRIAL DISASTERS MAY AFFECT LOCAL ENVIRONMENT?

Danger of failure and disaster originating from technological or industrial accidents, hazardous dangerous procedures, infrastructure collapse or certain human activities, which may cause the loss of human life or injury, damage of property , social , fiscal economic disruption or environmental deterioration. Industrial disasters are non-natural disastrous occurrences that include:

- Accident release -Occurring during the production, transportation or handling of hazardous materials
- Explosions - Disasters will only be classified as explosions when the explosion is the primary disaster. If the explosion is the cause of primary disaster, the event will be classified as the secondary disaster.
- Chemical explosion - Violent destruction caused by explosion of hazardous material, nearly always of chemical origin.
- Nuclear explosion/Radiation - Accidental release of radiation occurring in civil facilities, exceeding the internationally established safety levels.
- Mine explosion - Accidents which occur when natural gas or coal dust reacts with the air.
- Pollution - Degradation of one or more aspects in the environment by noxious industrial, chemical or biological wastes, from debris or man-made products and from mismanagement of natural and environmental resources.
- Acid rain - A washout of an excessive concentration of acidic compounds in the atmosphere, resulting from chemical pollutants such as sulphur and nitrogen compounds. When deposited these increase the acidity of the soil and water causing agricultural and ecological damage.
- Chemical pollution-A sudden pollution of water or air near industrial areas, leading to internal body disorders with permanent damage of the skin.
- Atmosphere pollution -Contamination of the atmosphere by large quantities of gases, solids and radiation produced by the burning of natural and artificial fuels, chemicals and other industrial processes and nuclear explosions

Industrial disaster results as a growth of industries throughout the nation and hence the small sectors and areas which are not a major hub of industries were also facing the problems of industrial disasters. It is an increasing phenomenon which directly depends upon demand and supply. The direct and continues negative impact of industries can be seen clearly in the environment as pollution. Pollution to a larger extent does not kil or hinder the entire civilization whereas industrial disaster has a capacity to complete vanish a civilization. Depending of where we live, hazards of industrial disasters fire, explosion, leakage, etc., are threats. to humans and environment, and also can have an impact on social indicators as seen after Bhopal disaster.

The growing incidence of natural disasters is highly correlated to the increasing vulnerability of households and communities in developing countries, as previous socioeconomic vulnerabilities may exacerbate the impact of a natural disaster, making more difficult the process of recovery (Vatsa and Krimgold, 2000).The same impact can be seen of industrial disaster that is now very much prevalent in today's spectrum. Thus, the impact of such industrial events could result in an immediate increase in risk and vulnerability of nearby population and environment.

The impact of an industrial man-made disaster may also cause inequalities. The lower sector of societies, who suffers from income fluctuations, and also have limited access to financial services, in the aftermath of a disaster may be more prone to reduce consumption and have a decreasing consternation in other household indicators as a consequence. In addition, there are a number of peoples, or close to be, who are not insured against from those industrial risks, and then may fall into serious trauma as consequence of de-capitalizing when coping with the consternation, depending the impact and likelihood of falling into trauma of the initial stock assets and coping mechanisms.

Moreover, vulnerability to industrial disasters is a complex issue, as it is determined by the economic structure, the stage of development, prevailing of social and economic conditions, coping mechanism, risk assessment, frequency and intensity of disasters, etc. The impact on the common people could be losing access to some basic services, reversals in accumulation of physical and human capital, and perhaps an increase in criminal activities.

One of the main queries regarding the impact of industrial chemical disaster on localities is how random they may be. Lindell and Prater (2003) also outline how the impact of natural disasters should take into account other mechanisms, such as mitigation practices emergency preparedness, assistance, etc., to determine the real impact. In addition, Donner (2007), analyzed the effects of tornadoes in the US and found that the effect are not random, because some factors such as environmental, organization, demographic, and technological, have an incidence on the impact of such events. If such type of primary disaster results in secondary disaster then the devastation can be much more than anybody can imagine. Chernobyl was an example of such disaster.

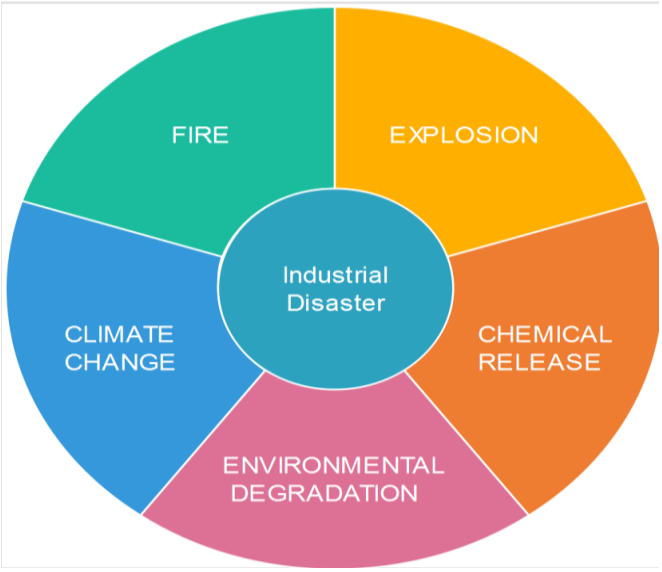


Figure 1. Industrial Disaster Impact Model

Industrial disaster phenomenon as shown in figure 1 broadly results in fire, explosion, chemical release, climate change and environmental degradation etc. which is more serious then natural disaster. Apart of these hazards there are various other hazards like loss of crop, livelihood, life, basic amenities like water, food, medicine etc. are other requirements whose unavailability cause generation of disastrous situation.

SIIDCUL Industrial Unit Haridwar

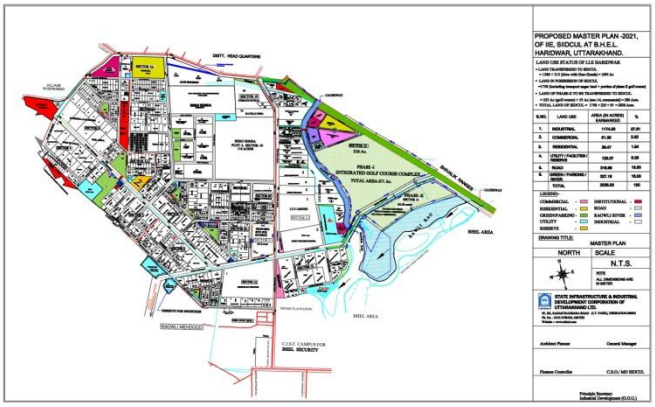


Figure 2. Proposed master plan-2021, of IIE, SIIDCUL at B.H.E.L Haridwar, Uttarakhand

Integrated Industrial Estate, Haridwar is located just 3 Km from Delhi-Haridwar National Highway, 225 Km from National Capital Delhi & 52 Km from State Capital Dehradun. Total area of industrial estate is 2034 acres. The proposed industrial area in SIIDCUL is Cosmetics & Allied, Plastic & Allied, Apparel & Allied, Agro Food & Allied, Pharmaceutical Products,

Electrical, Electronics & Allied, Institutional, and Commercial & Allied.

Simply taking the example of pharmaceutical industry where in a large number of workers are indulge in manufacturing , processing , packaging etc. , provides some basic information of occupational hazards like cancer, endocrine dysfunction, cancer, and liver disease & the probability of conversion of these minute hazards into major biological disaster . So it is very much obvious that primary disaster of chemical industrial units apart from basic hazards like fire, explosion, leakage etc. can also be converted and comes into existence as a big source of biological or environmental disaster.

Secondary the level of pollution increment is rapid in nearby areas. The continuous disposal of hazardous material even after treatment for long time can results in a form of secondary disaster. All these are gray areas which basically results as a new form of chemical industrial disaster.

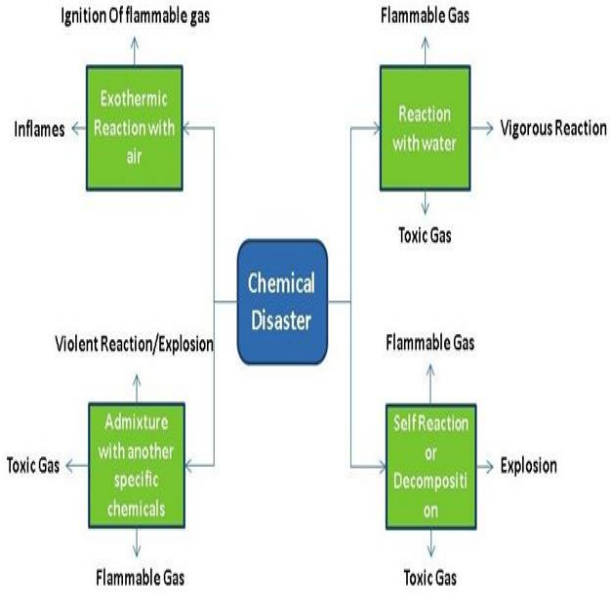


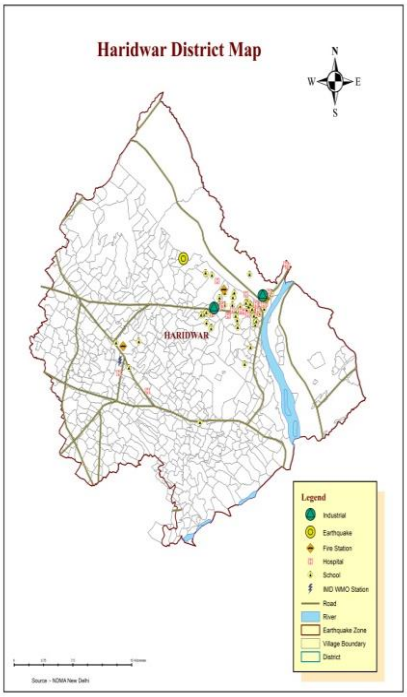
Figure 3. Effects of chemical disaster

Chemical disaster generally produces flammable gas, explosion, and toxic gases. The properties of chemicals are such that if they are in uncontrollable condition than it can cause severe damage to humans as well as the environment. The impact can be seen so dreadful which can be beyond imagination as seen during Bhopal disaster wherein methyl isocyanate (MIC) kills several number of peoples and injured people in thousands. The same condition exists with each and every industrial unit, and SIIDCUL is one of them where the possibility of such leakage, fire, explosions etc. can occur any time.

III. METHODOLOGY, DATA AND VARIABLES

The method to develop exact location of industrial units, their boundaries and hazards zones as per the variables like population, road network, infrastructure etc. can be found by using GIS platform .It will help to get various data variables like population, schools, infrastructure, hospitals, crowded areas, market etc. that will be streamlined to analysis disaster risk if any failure, accident or terrorist attack occurs within the boundaries of industrial unit and hence raining of level three alarm. Level three alarms denote the involvement of district administration involvement in mitigating the effects of disaster as the situation can't be handled now by local industry officials. The mappings of all the key points are done by using GIS platform which helps us to know the major probable hazard, risk and vulnerability inside and nearby the industrial units.

Along with using GIS platform, the incorporation of CAMEO & ALOHA software to do a predictive analysis of hazardous material spillage will provide a complete set of data variables that can be useful in assessing industrial disaster threats in Haridwar. The various parameters are population data, demography details, transportation routes for heavy vehicles, wind velocity, humidity of district, flood zone which passes through industrial area etc. All the data in a combine manner will help to evaluate the impact of natural disaster on Haridwar and its conversion into secondary industrial disaster



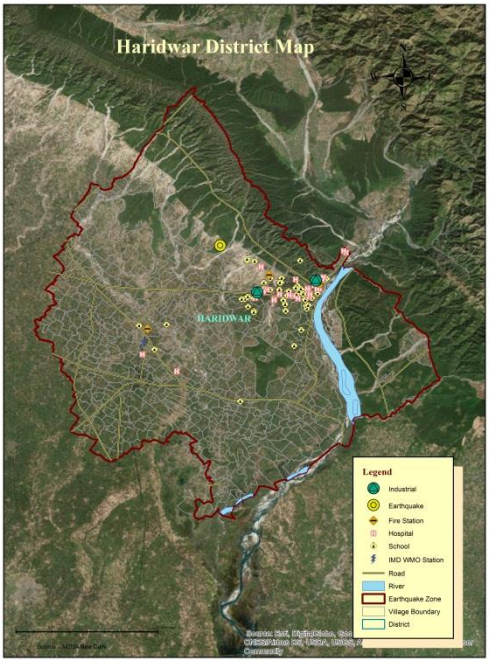


Figure 4. GIS map of Haridwar District

The set of data assessed via ALOHA software comprises of Site location i.e., Haridwar , Chemical data taken is of Chlorine , atmospheric data has been computed manually wherein the wind speed considered as 4 meter/second ,threat zone as heavy gas selected and 292,000 ppm outdoor ,2,940 ppm indoor exposure has been found. The data has been shown in Chart 1 ALOHA data for chlorine leakage in Haridwar

File Edit SiteData SetUp Display Sharing Help

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SITE DATA:
  Location: HARIDWAR, INDIA
  Building Air Exchanges Per Hour: 0.53 (unsheltered double storied)
  Time: March 23, 2018  0204 hours ST (using computer's clock)

CHEMICAL DATA:
  Chemical Name: CHLORINE
  CAS Number: 7782-50-5                Molecular Weight: 70.91 g/mol
  AEGL-1 (60 min): 0.5 ppm   AEGL-2 (60 min): 2 ppm   AEGL-3 (60 min): 20 ppm
  IDLH: 10 ppm
  Ambient Boiling Point: -30.7° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 4 meters/second from 1° true at 3 meters
  Ground Roughness: open country       Cloud Cover: 5 tenths
  Air Temperature: 30° C               Stability Class: D
  No Inversion Height                  Relative Humidity: 50%

SOURCE STRENGTH:
  Direct Source: 50 liters             Source Height: 1 feet
  Source State: Liquid
  Source Temperature: 52° C
  Release Duration: 1 minute
  Release Rate: 2.4 pounds/sec
  Total Amount Released: 144 pounds
  Note: This chemical may flash boil and/or result in two phase flow.

THREAT ZONE: (HEAVY GAS SELECTED)
  Model Run: Heavy Gas
  Red   : 1017 yards --- (20 ppm = AEGL-3 [60 min])
  Orange: 1.5 miles --- (2 ppm = AEGL-2 [60 min])
  Yellow: 2.5 miles --- (0.5 ppm = AEGL-1 [60 min])

THREAT AT POINT:
  Concentration Estimates at the point:
  East: 0 meters                       North: 0 meters
  Max Concentration:
     Outdoor: 292,000 ppm
     Indoor:  2,420 ppm
```

Chart 1. ALOHA data for chlorine leakage in Haridwar

The time taken for study is March 23, 2018 and the wind flow was 4 meters/ second as shown in Chart 2. Air temperature at the time of data collection was 30 degree Celsius.

Time: March 23, 2018 0041 hours ST
Chemical Name: CHLORINE
Wind: 4 meters/second from 1° true at 3 meters

THREAT ZONE

Red	1017 yards	20 ppm = AEGL-3 (60 min)
Orange	1.5 miles	2 ppm = AEGL-2 (60 min)
Yellow	2.5 miles	0.5 ppm = AEGL-1 (60 min)

Model: ALOHA Heavy Gas

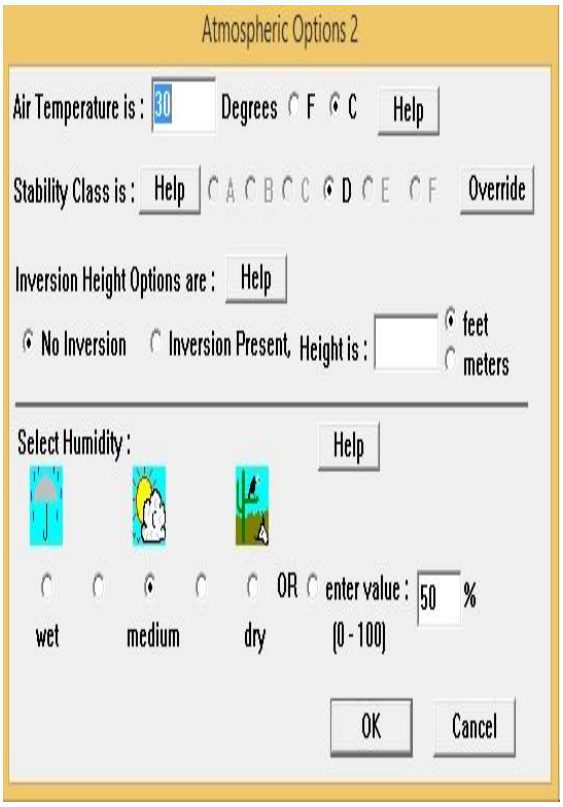


Chart 2. ALOHA Heavy gas Model and Atmospheric Option selection Procedure

Creating buffer zone and selection of buffer zone i.e, 5 kms , figure 5 and checking concentration at indoor and outdoor locations in the districts are shown in Graph 1.

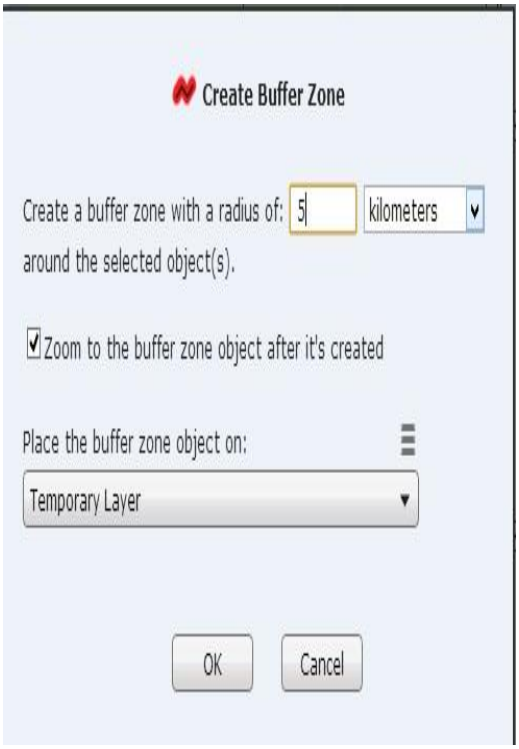
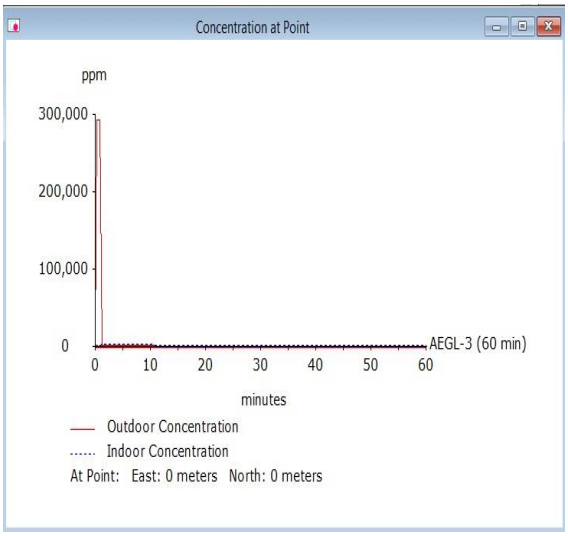


Figure 5. Buffer Zone Creation



Graph 1. Concentration assessment

Further step is to check infiltration building parameters where it is considered that the location is double storied unsheltered building and the number of air changes per hour is 0.53 as per hour. The volume input data has also been considered a shown in figure 6.

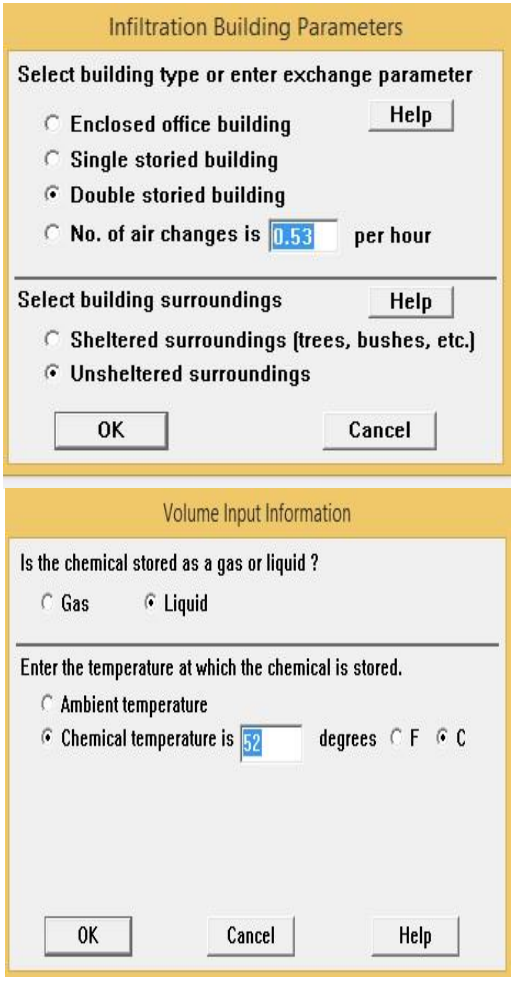


Figure 6. Infiltartion buidling Parameters & Volume Input information

The parameters of direct soruce has been taken as 50 litres which seems to an instantaneous source and the height of leakage has been assumed as 1 feet above the gorund.Concentartion location in Figure 7 shows the coordinates of location whwre leakage took place along with the direction of wind at the time of leakage .The concetartion location helps to specify the location wghich is required to evaluate the concentration over time.

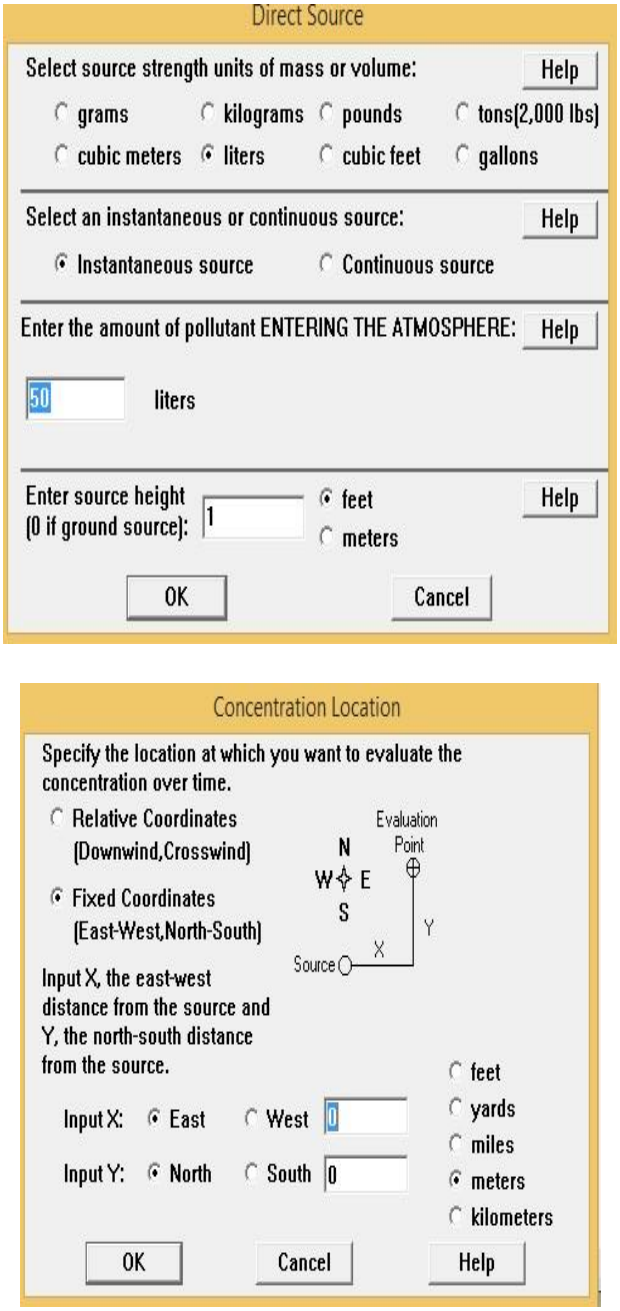


Figure 7. Direct Source and Concentration Location

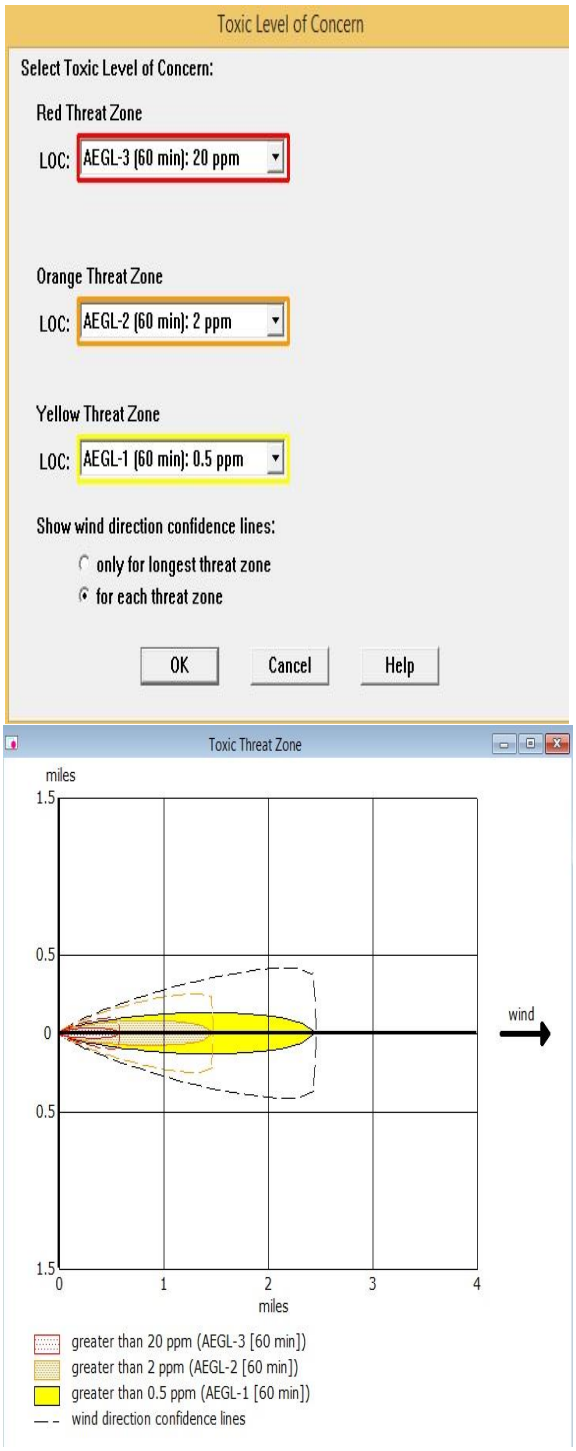


Figure 8. Toxic level of Concern and toxic threat zone

Acute Exposure Guideline Levels (AEGLs) estimate the concentrations at which most people—including sensitive individuals such as old, sick, or very young people—will begin to experience health effects if they are exposed to a hazardous chemical for a specific length of time (duration). Red, Orange & Yellow shows the toxic level of concern (LOC).By considering all these points the graph of toxic threat zone provides us a flow chart of chemical leakage by considering area in miles and the wind velocity at

that time. The second graph of figure 8 shows the same graphical representation of toxic threat zone.

IV. RESULTS

The final outcome is MARPLOT of Chlorine leakage in SIIDCUL industrial area Haridwar which has been shown in the Figure 9. It provides an overview of the vulnerable location that might probably get exposed due to leakage of hazardous chemical (chlorine). The extent up to which contamination can reach has been predicted by using the ALOHA , CAMEO & MARPLOT software's. The date and time considered is 23rd March and the time taken is 2:36:37 am .The leakage was assumed to took place in SIIDCUL industrial area Haridwar and the figure shows that the leakage if took place under the above provided data an reach up to river stream and can contaminate water body to. The directions of wind velocity have been shown clearly in the figure and the red as well as the yellow zone indicates the extent of Acute Exposure Guideline Levels (AEGLs) near the incident point. The toxic level of concern can very well analyzed and pointed in the figure. The circle shows the probable area up to which exposure reach can easily if the leakage occurs.

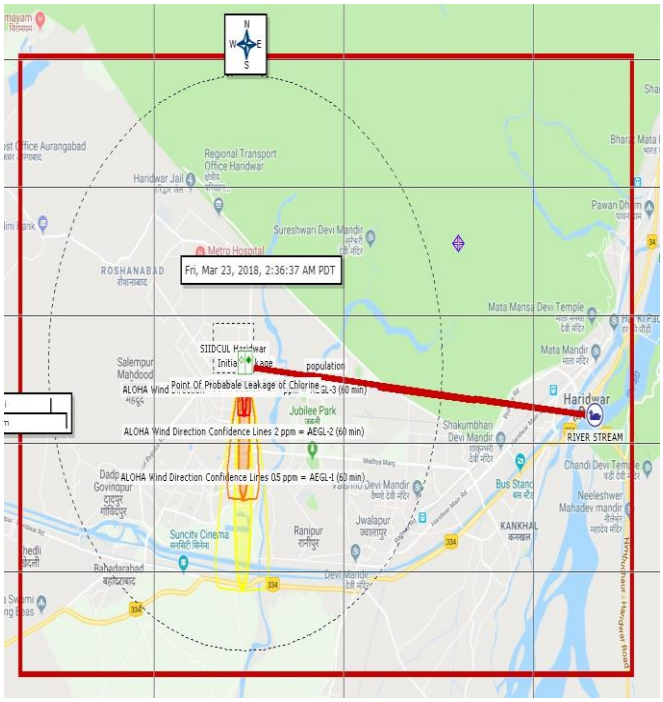


Figure 9. MARPLOT of Chlorine Leakage

V. CONCLUSION

Chemical industrial accidents have become common events in recent years; especially near major accidental units. The debate on whether such events are potentially affecting the development of affected areas is still under way. In this context, this paper analyzes a dataset for local indicators at SIIDCUL industrial area Haridwar. We specifically analyze the impact on the chemical leakage. We used real time based climatic condition with the help of software's to analyze the real picture in case leakage takes place and the extent it acquired if the incident of chemical industrial takes place in the Haridwar district. We are able to locate the points up to where the leakage can reach by making the population of that location vulnerable.

Results show that there is a significant impact from chemical industrial disasters on population nearby that location and the reach of such disaster can increase very sharply and can reach a great distance. Floods , heat wave , strong wind etc. are the more significant natural events if got connects with chemical disaster may affect a major segments of society causing the local responders a tough time to mitigate the effects of these disaster.

This paper has made a contribution to the debate on the impact of increasing combination of manmade disaster to natural disaster events. As it has been shown that such events reduce the preparedness at the local level, public policies for attenuating such impacts must be more focused on those living in these areas and in implementing disaster mitigating mechanisms for keeping elements considered in the disaster risk reduction measures that are affected due to these shocks. Additional research could focus on the micro effects of natural and man-made disaster on the environmental conditions, populations and mitigation strategies.

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