Off-site Emergency Planning for MAH Industries in India

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Paper Abstract

Rapid industrialization and increased usage, production, transportation, and handling of chemicals have resulted in a number of serious chemical accidents such as the Bhopal gas tragedy--the worst chemical disaster in history. Ministry of Environment and Forests (MoEF), government of India, has done tremendous efforts to minimize such accidents and to improve emergency preparedness at district, state, and center levels. To further improve the preparedness level, a GIS-based system is being developed to aid off-site emergency planning for MAH Industries in India. The work envisages developing comprehensive user-friendly software using MapObjects with database of Major Accident Hazard (MAH) units, hazardous chemicals stored, resources available to combat emergency. Exact location of the unit, vulnerable zonation (through CAMEO suit and ARCHIE), resources available for emergency management (fire, medical, police, transport, shelters, etc.), along with their locations and data on surrounding MAH units, have been studied.

1.0 INTRODUCTION

The off-site Emergency Planning for MAH Industries in India is essential due to rapid industrialization has increased usage of chemicals. This leads to increased storage, production, transportation and handling resulting in number of serious chemical accidents affecting surrounding communities in a very short span of time and mostly without any warning. India, although developing, is one of the highly industrialized country in the world. It has been the endeavour of successive governments to make India self reliant in almost all types of industries and products. The rapid growth in large number of hazardous chemicals has significantly increased the potential of accident involving such chemicals. In past, many of these accidents have lead to large scale loss of life, damage to environment and property. Trauma of Bhopal Gas tragedy is still fresh in our memories where in couple of hours over 2000 people died due to accidental release of toxic Methyl Isocyanate (MIC). Therefore it is pressing need of time to understand the potential of chemical emergencies and develop tools for offsite emergency planning and response to minimize the damage in case of any eventuality. The present work, details of which are given in ensuing paragraphs, is an important step in this direction. Disasters have always posed a serious threat to human life and it has been a matter of great concern for eminent scientists, technocrats and decision makers. Disasters can be divided into two major categories - natural disasters such as earthquakes, cyclones, floods, etc. and manmade disasters such as chemical accidents, terrorism, chemical/biological war, etc. With technological advancement, substantial efforts are being made to predict the occurrence of natural disasters, assess the damage potential and to take precautionary measures to mitigate their effects. However, on other hand, technological advancements have also increased the occurrence of manmade disasters.

Outcome of chemical accidents can be broadly categorized as fire, explosion and toxic release depending upon characteristics of a chemical involved in an accident along with other critical factors such as storage/processing characteristics, availability of ignition source, etc. Meteorological conditions such as wind speed, wind direction, height of inversion layer, stability class, etc. also play an important role by affecting the dispersion pattern of toxic gas cloud. With the help of computer simulation models, knowledge of chemicals';it's behavior and availability of input data, it is possible to predict the area affected under different emergency scenarios. Further to assess the damage and carry out emergency planning and response exercise, it is essential to overlay the outcome on a map having features such as other industries, residential areas, schools, markets, road, rail, etc. Also the resources required such as fire and spill control, medical aid, etc. to combat the emergency situation arising out of chemical accident, their location and access to site of accident can also be plotted. Keeping in view the plotting requirement along with linkages of various databases, it has been considered appropriate to use GIS tools for off site emergency planning and response.

The application "Off-site Emergency Planning for MAH Industries in India" is sponsored by Ministry of Environment & Forests (MoEF), Government of India, which is nodal ministry dealing with chemical disasters in India. It is executed by National Informatics Center (NIC), Ministry of Communication and Information Technology, Government of India.

2.0 MAJOR PROJECT COMPONENTS

The major components are as:

1. Identification of Chemical Industries in the study area covering major states of India.

2. Database Design.
3. Collection of data pertaining to chemical storage and handling from identified industries.
4. Collection of resource data in terms of fire fighting equipment and stocks, Personal Protective Equipment (PPE), transportation facilities, etc. from industries
5. Collection of data on resources available with government authorities such as police, fire and medical departments
6. Collection of spatial data with the help of GPS handsets for chemical industries, first responders – police, fire and medical and sensitive areas such schools, cinemas, etc.
7. Identification and procurement of SOI toposheets for the study area
8. Geo-referencing and Digitization of toposheets
9. Chemical accident simulation using computer models for all the identified chemical accident scenarios.
10. Development of front-end menu-driven software linking spatial data, scenario templates, industry data, resource data and response information data sheets (RIDS) for each chemical.

3.0 STUDY AREA

Major Accident Hazard Units are spread across the length and breadth of India. These MAH units are often found in clusters located within notified Industrial estates though some are outside in isolated locations. To manage chemical emergencies arising out of hazardous material releases from such clusters of MAH units requires great planning and co-ordination between several agencies simultaneously. The response to possible chemical emergencies is a subject of great concern to the nodal ministry for co-ordination of chemical emergencies, namely the Ministry of Environment and Forests (MoEF), Government of India.

In India the major clusters of Industries are in Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu States. Also the project cover districts with major industrial clusters in ten other states namely Rajasthan, Uttar Pradesh, Haryana, Punjab, Madhya Pradesh, Assam, West Bengal, Kerala, Karnatka and NCT. These 14 states comprise those with the bulk of MAH industries in the country.

Extensive data collection exercise was undertaken to collect the first hand information (primary data) from all the industrial units and district level response agencies for all the major districts in fourteen states. To cover the surroundings of MAH industries in these districts, the corresponding toposheets were procured for complete coverage:

First responders i.e. Police stations, fire stations, hospitals/nursing homes and sensitive areas – schools, colleges, cinemas, etc. surrounding the identified industrial units, were also identified for data collection.

4.0 METHODOLOGY

Identification of Chemical Industries

As per the Manufacture Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989 and as amended in 2000, Major Accident Hazards (MAH) installations, means - isolated storage and industrial activity at a site handling (including transport through carrier or pipeline) hazardous chemicals equal to or, in excess of the threshold quantities specified in, column 3 of schedule 2 and 3 respectively of the rules. Chief Inspector of factories at state level maintain a list of such factories in their states and such industries in short listed districts were identified based on the latest data maintained by them.

Database Design

Database design were undertaken to facilitate data storage and for easy retrieval. Data of all the chemical industries, their chemicals and resources; data of first responders, data of sensitive areas; data on output of computer models in terms of .pas files, RIDS data, spatial data on locations; raster data on images of toposheets, etc. have been stored in databases, and linked through front end menu driven software.

Database design has been done considering the following things:

- Information on MAH units
- Resources Available with MAH units for emergency management
- Data on Response Agencies
- Resources Available in District/Clusters
- Sensitive Areas

Chemical and Resource Data from MAH industries

With the help of chemical experts questionnaires the chemical and resource data from MAH industries were collected. All the information required for developing the package were collected through visit to the identified industries so that first hand, factual and correct data is collected. Information related to handling of hazardous chemicals, their storage and processing conditions, quantities, safety measures, etc. formed the content of this questionnaire. A separate section of the questionnaire dealt with the information on resources available with the industries to manage chemical accidents. Such resources mainly include fire fighting equipment and stocks, spill control equipment, PPEs, etc.

Resource Data from Government Authorities

For any chemical accident, police, fire and medical services at local level are considered to be first responders. Therefore it is important to collect data in terms of their location and resources available with them for emergency planning. Separate questionnaires were developed to collect resource data and their contact information for local authorities. Based on the location of MAH industries, police stations, fire stations, government and private hospitals in the vicinity were identified and data was collected from them through the questionnaire. Such data include the number and type of fire tenders, PPEs, etc. with fire services and facilities available at hospitals for treatment of burn patients and chemical poisoning patients, etc.

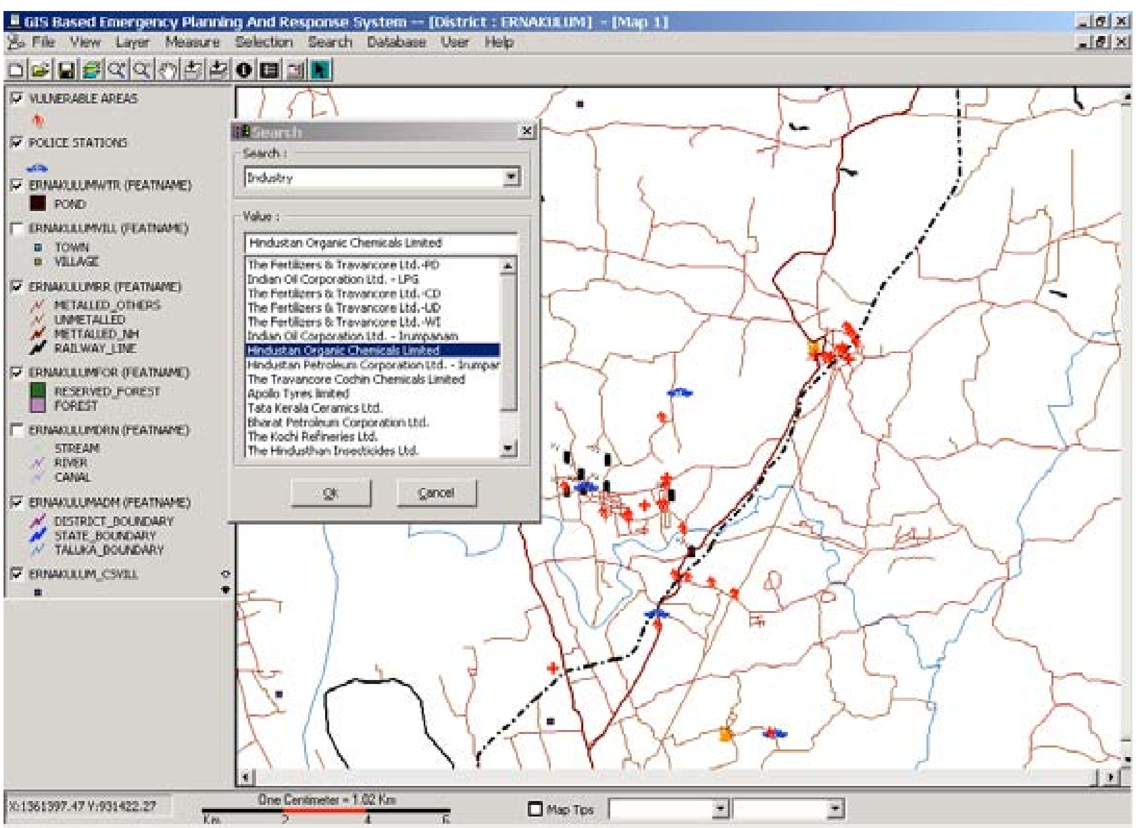
GIS Based Emergency Planning And Response System -- [District : ERNAKULUM] - [Map 1]
File View Layer Measure Selection Search Database User Help
VULNERABLE AREAS
POLICE STATIONS
ERNAKULUMWTR (FEATNAME)
POND
ERNAKULUMVILL (FEATNAME)
TOWN
VILLAGE
ERNAKULUMRR (FEATNAME)
METALLED_OTHERS
UNMETALLED
METTALLED_NH
RAILWAY_LINE
ERNAKULUMFOR (FEATNAME)
RESERVED_FOREST
FOREST
ERNAKULUMDRN (FEATNAME)
STREAM
RIVER
CANAL
ERNAKULUMADM (FEATNAME)
DISTRICT_BOUNDARY
STATE_BOUNDARY
TALUKA_BOUNDARY
ERNAKULUM_CSVILL
Search
Search :
Industry
Value :
Hindustan Organic Chemicals Limited
The Fertilizers & Travancore Ltd.-PD
Indian Oil Corporation Ltd. - LPG
The Fertilizers & Travancore Ltd.-CD
The Fertilizers & Travancore Ltd.-UD
The Fertilizers & Travancore Ltd.-WI
Indian Oil Corporation Ltd. - Irumpanam
Hindustan Organic Chemicals Limited
Hindustan Petroleum Corporation Ltd. - Irumpar
The Travancore Cochin Chemicals Limited
Apollo Tyres limited
Tata Kerala Ceramics Ltd.
Bharat Petroleum Corporation Ltd.
The Kochi Refineries Ltd.
The Hindusthan Insecticides Ltd.
Ok
Cancel
X:1361397.47 Y:931422.27
One Centimeter = 1.02 Km
Km 2 4 6
Map Tips

Fig. 1 (Industries and resource data)

Collection of Spatial Data

Spatial data in terms of latitude and longitude were collected for all the MAH industries, police stations, fire stations, hospitals, sensitive areas – schools, colleges, cinemas, etc. Such data was collected through physical survey of the area using handheld GPS instrument.

Procurement, Geo-referencing and Digitization of toposheets

All the required toposheets were procured, scanned, digitized and mosaiced to create district wise profile as shown in fig.2. Geo-referencing was done for synchronization of vector and raster data for authentication.

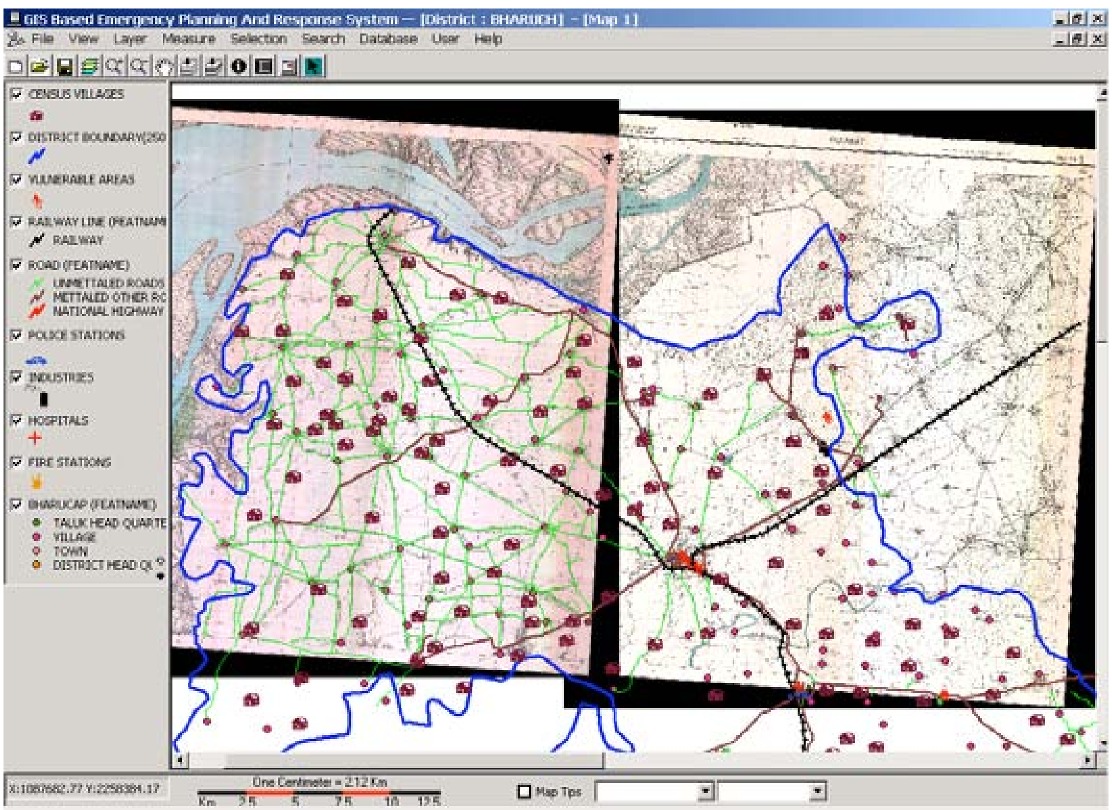

Fig. 2 (Mosaiced toposheets along with district boundaries)

Computer Simulation Modeling

Chemical data collected from MAH units formed the basis of this activity. Data sets were compiled chemical wise along with their quantities and storage conditions. Based on the characteristics of the chemicals various possible Maximum Credible Loss (MCL) scenarios were listed and computer simulation was carried for such scenarios. The following criteria as laid down by the MoEF is considered, viz: catastrophic rupture (release of Inventory within a minute or so from a single container for toxic chemicals and for the grouped inventory in case of flammable material), IDLH value cutoff for toxic chemicals , 4 kw/m2 heat radiation cutoff for fires, 0.1 bars peak overpressure for explosions. Whenever multiple offsite scenarios are present, the model would provide predetermined hazard zones chemical wise. The MCLs are mainly worked out for the storage scenarios and also for process scenarios, if necessary. Various identified computer models such as ARCHIE, ALOHA, CAMEO, etc. are used for delineation of vulnerable zones chemical wise. The consequence calculations were performed as per the guidelines of the MoEF, using worst-case meteorological conditions (stability class D with 3 m/s of wind speed and stability class F with 1.5 m/s of wind speed). This allow highly realistic hazard zone mapping depending upon the wind conditions at the time of incident.

Computer modeling has been done for all the hazardous chemicals stored at the MAH units so that vulnerable zone for each chemical is delineated under different combinations of meteorological conditions. Whenever multiple offsite scenarios are present, the model provides hazard zones chemical wise. The MCLs are mainly worked out for the storage scenarios and process scenarios. Where clusters of MAH Units are present, the Vulnerability template indicates units, which could cause knock on effect onto the MAH Unit in a 2-way mode.

The computer model provides complete interactivity to emergency management authorities to find the actual hazard zone and how it can change with time and meteorological conditions, by minimum data input.

This Vulnerable Zone data is mapped onto the base map both as text in box and also graphically, to allow visual display.

Development of Front-end Menu-driven Software

To provide the user friendliness to the whole package, a front-end menu driven software has been developed in visual basic using Map Objects interface. It has been designed and customized keeping in mind the type of information required by the response agencies at district emergency control centers and also the skill level of the expected users at the district and state level. With these objectives, following section details the options available to users for accessing the desired information. The package has been provided with a password to prevent unauthorized use.

5.0 SOFTWARE OPERATION

Accessing MAH Data

Once the software is loaded, all the layers, viz. MAH, first responders, amenities and sensitive areas, villages, etc. will be available by default and the user has been provided with the option of opening the desired layers. These also include the scanned SOI toposheets for each district. The menu-driven software provides option for selecting the MAH unit from the drop down list of MAH units in the district.

Once the unit has been selected, all its information such as address, name of contact persons, telephone numbers, nature of activity, major hazardous chemicals handled, resources in terms of medical, fire fighting, PPEs, and vehicles available can be viewed. Simultaneously, its location will start blinking on the base map.

The user can also draw a circle as the zone of interest and obtain a list of MAH units falling in that zone. Again the user can select the MAH unit from the list to get complete information as given above.

Accessing Data on Response Agencies

Police, Fire and Medical services are the first responders in a chemical emergency situation. Prompt availability of data on these responders is crucial in rendering first response. A search tool has been provided to select either Police/Fire/Medical resources available in the district. Clicking on the desired group will provide user with the list of Police stations/Fire Stations or Hospitals in the district.

Clicking on the desired police station will provide user with the contact information of the police station and simultaneously its location will also be highlighted on the base map.

Similarly clicking on the desired fire station from the list will provide its contact information along with fire fighting facilities and resources available such as number of fire tenders available, number of fire entry/proximity/SCBA suits available, etc. Its location will also be highlighted on the base map.

Clicking of the Hospital will provide contact information of the hospital and also facilities and resources available with it such as number of beds, burn/chemical poisoning treatment facility available, number of ambulances available, etc. As for above cases, location will be highlighted on the base map.

Accessing Data on Amenities and Sensitive Areas

These are a special set of locations, which either serve as resource points during a chemical emergency or serve a large number of people and may therefore be particularly vulnerable during such an event. Such locations have been identified in each district especially those located close to the MAH units. Information on their location can also be obtained from the software menu.

Response Information Data Sheets (RIDS)

The software provides separate tool for accessing response information on each of the identified chemicals for every district. RIDS provide complete information about the particular chemical properties such as its physical and chemical properties, fire hazards and fire fighting measures, health hazards and PPEs, etc. RIDS is available under the help button, the user can select the desired hazardous chemical from the list available and view its complete information. The user can also access RIDS by double clicking the desired chemical under chemical information of any industry.

Planning Tool for Response to Chemical Accident

This is a very powerful tool for strategic planning and resource identification for responding to chemical accidents. Three types of accidents have been envisaged viz. Fire, Explosion (BLEVE/UVCE) and Toxic Vapour Dispersion.

Once the Unit has been selected based on above procedure, the user can go to its chemical information and select the concerned chemical. Here the user has been provided with the choice of accident simulation and also Response Information Data Sheets (RIDS).

Double clicking the chemical will provide him with complete information about that particular chemical. However, clicking on the Accident Scenarios will provide him with options of fire/explosion and toxic vapour release, as the case may be based on the properties of the chemical concerned.

Taking an example of ethylene oxide, which has the potential of all three types of accidents, clicking on fire will give user the fatality zone radius and injury zone radius (in meters) surrounding the chemical storage. Similarly selecting the explosion scenario will also give him results of fatality zone radius and injury zone radius surrounding the storage. In both these cases it will draw two concentric circles (inner one for fatality zone and outer for injury zone) on the base maps with concerned MAH units at its center as shown in fig. 3 above.

Selecting the toxic vapour dispersion hazard will prompt the user for selecting time of the day (day or night time conditions to reflect difference in atmospheric stability class conditions) and then the wind direction. Once these inputs are provided, a plume footprint will be generated and will be visible on the base map. This plume also has two zones. The inner zone reflects the zone of confidence where IDLH concentration is likely to be present 99% of the times and the outer zone reflects likely hazard zone which may get affected due to shift in wind direction.

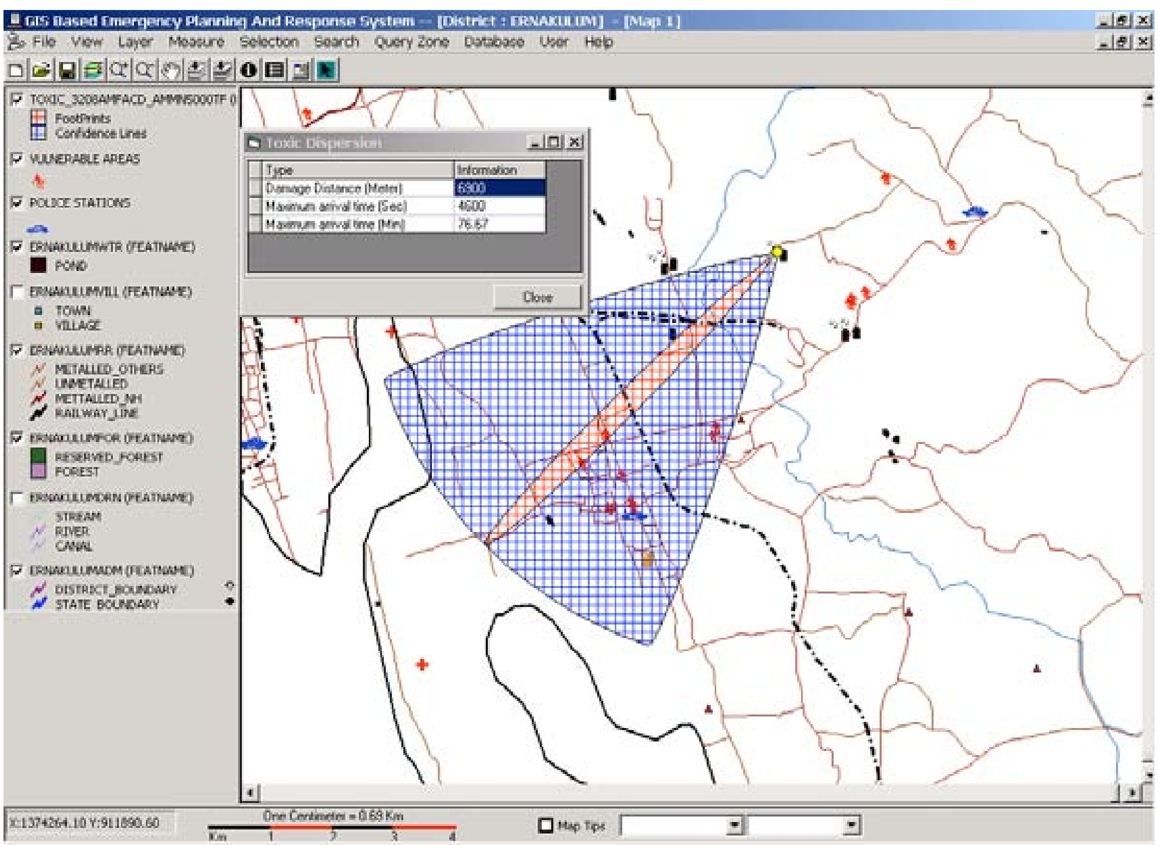

Fig 3 (Plume showing fatal zone in red and injury zone in blue)

The next step in strategic planning is identification of vulnerable location within these hazard zones. For this the user can easily query the software and obtain list of MAH units, first responders, amenities and sensitive areas within these zones. The user can also draw a buffer zone of his choice keeping the affected MAH unit as its center. With this buffer zone he can query the software and obtain list of first responders for rendering prompt emergency response.

Another very important and useful feature of this software is that it can provide user with the number of people likely to be present within the hazard zone. This figure is obtained from the MAH data and the village data over which the hazard zone exists. This number is very useful in estimating the extent of evacuation and related measures required during chemical emergency.

6.0 Acknowledgement

The application on off-site Emergency Planning for MAH Industries in India is sponsored by Ministry of Environment & Forests, Government of India and executed by National Informatics Centre, Department of Communications and Information Technology, Government of India.

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7.0 END NOTES

The application on Off-site Emergency Planning for MAH Industries in India is a unique approach, first of its kind integrating Spatial and non-spatial data on to a single GIS based system. The application has successfully delivered a highly interactive menu driven, user-friendly customized package for non-specialist end users at local level. Also it has delivered a powerful versatile digital geo-referenced database of maps, images, MAH data (locations, Contact personnel, chemicals etc), vulnerability Zones, district resource data (fire, hospitals, police etc.) as national asset. The project needs to cover remaining additional clusters with high concentration of MAH units for national perspective.

8.0 APPENDIX

INDUSTRY QUESTIONNAIRE

1. **General**

Name of the Unit			
Address			
Latitude			
Longitude			
Key Person			
Designation			
Phone (Office)			
Phone (Residence) Mobile			
Nature of Activity of the Industry			
Total Number of Employees			

2. Storage of Hazardous Chemicals

a) Kindly provide details of hazardous chemicals stored at your facility:

Sr. No.	Example	1	2	3
Hazardous Chemical	Motor Spirit			
Type of Storage	Vertical Cyl. 'Tank			
No. of Storages	2.			
Total Quantity\ Stored	25000 KL			
Dimensions of largest storage	1: Dia 1m, H: 1Om			
Quantity in largest Storage unit	1: 15000 kl			
Storage Temp. Pressure	Ambient Ambient			
Dyke Dimensions (if applicable)	Area 240 m2 L:20m, B: 12m H:1.5m			.

3. Emergency Response Facilities at the Plant

a) Medical facilities

Item	Quantity
No. of Beds in Medical Room	
Availability of Full Time FMO	
Stock of medicines/antidotes	
Ambulance	

b) Fire fighting facilities

Item	Quantity	Item	Quantity
Water tenders		Fire water reservoir (capacity m3)	
Foam tenders		Any other	

DCP Tender			

c) Personal protective equipment

Item	Quantity
PVC Suit with hood for full body protection	
Industrial type canister masks	
Self Contained Breathing Apparatus (including usage time)	
Fire entry suit	
Fire proximity suit	
Chemical Splash suit	
Emergency Kit	
Water Gel	
Any other	

d) Transportaion facilities(which can be used during emergency)

Vehicle	**Quantity**	**Item**	**Quantity**
Buses		Cars	
Trucks		Jeeps	
Vans		Vehicles with siren/ PA System	

Industries Database for Ernakulum district

I_CODE	Name
3208FCFAWI	The Fertilizers & Travancore Ltd.-WI
3208AMFACD	The Fertilizers & Travancore Ltd.-CD
3208NDIOCL	Indian Oil Corporation Ltd. - LPG
3208UGFAPD	The Fertilizers & Travancore Ltd.-PD
3208UGFAUD	The Fertilizers & Travancore Ltd.-UD
3208IPIOCM	Indian Oil Corporation Ltd. - Irumpanam
3208AMHOCL	Hindustan Organic Chemicals Limited
3208IPHPCL	Hindustan Petroleum Corporation Ltd. - Irumpanam
3208UGTCCL	The Travancore Cochin Chemicals Limited
3208KLAPTL	Apollo Tyres limited
3208ERTKCL	Tata Kerala Ceramics Ltd.
3208IPBPCL	Bharat Petroleum Corporation Ltd.
3208AMTKRL	The Kochi Refineries Ltd.

I_CODE	Name
3208UGTHIL	The Hindusthan Insecticides Ltd.
3208UGMRCH	Merchem Ltd.
3208UGBSES	BSES Kerala Power Ltd.
3208BPTBZL	The Binani Zinc Ltd.

Database of Scenarios for different chemicals

T_Code	Scenario
3208AMFACDAMMN5000TD	Toxic vapour dispersion due to catastrophic failure of 5000 MT Ammonia storage during day time
3208AMFACDAMMN5000TF	Toxic vapour dispersion due to catastrophic failure of 5000 MT Ammonia storage during night time
3208AMFACDARTX0020DC	Catastrophic failure of 0.5 MT Arsenic Pentoxide storage
3208AMHOCLACTN0593PF	Pool fire due to catastrophic failure of 593 MT Acetone storage tank
3208AMHOCLBNZN0882PF	Pool fire due to catastrophic failure of 882 MT Benzene storage tank
3208AMHOCLBNZN0882TD	Toxic vapour dispersion due to catastrophic failure of 882 MT Benzene storage tank during day time
3208AMHOCLBNZN0882TF	Toxic vapour dispersion due to catastrophic failure of 882 MT Benzene storage tank during night time
3208AMHOCLLQPG1540BL	BLEVE due to catastrophic failure of 1540 MT LPG sphere
3208AMHOCLLQPG1540UV	UVCE due to catastrophic failure of 1540 MT LPG sphere
3208AMTKRLATFL5360PF	Pool fire due to catastrophic failure of 5360 MT ATF storage tank
3208AMTKRLBNZN3155PF	Pool fire due to catastrophic failure of 3155 MT Benzene storage tank
3208AMTKRLBNZN3155TD	Toxic vapour dispersion due to catastrophic failure of 3155 MT Benzene storage tank during day time
3208AMTKRLBNZN3155TF	Toxic vapour dispersion due to catastrophic failure of 3155 MT Benzene storage tank during night time
3208AMTKRLCRDE7680PF	Pool fire due to catastrophic failure of 7680 MT Crude Oil storage tank
3208AMTKRLKRSN4960PF	Pool fire due to catastrophic failure of 4960 MT Kerosene storage tank
3208AMTKRLLQPG1400BL	BLEVE due to catastrophic failure of 1400 MT LPG

T_Code	Scenario
	sphere
3208AMTKRLLQPG1400UV	UVCE due to catastrophic failure of 1400 MT LPG sphere
3208AMTKRLLSHS7462PF	Pool fire due to catastrophic failure of 7462 MT Diesel storage tank
3208AMTKRLNPTH6216PF	Pool fire due to catastrophic failure of 6216 MT Naphtha storage tank
3208AMTKRLPTRL4144PF	Pool fire due to catastrophic failure of 4144 MT Motor Spirit storage tank
3208AMTKRLPTRL4144UV	UVCE due to catastrophic failure of 4144 MT Motor Spirit bullet
3208AMTKRLTOLU0867PF	Pool fire due to catastrophic failure of 867 MT Toluene storage tank
3208BPTBZLLQPG0019BL	BLEVE due to catastrophic failure of 19 MT LPG bullet
3208BPTBZLLQPG0019UV	UVCE due to catastrophic failure of 19 MT LPG bullet
3208ERTKCLLQPG0050BL	BLEVE due to catastrophic failure of 50 MT LPG bullet
3208ERTKCLLQPG0050UV	UVCE due to catastrophic failure of 50 MT LPG bullet

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