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Risk Management for Chlorine Producing Factory in Egypt

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Abstract: Recent events raised the issue of safety and emergency preparedness for all people in the country. They included industry-related events that cause serious damage to the environment and loss of the life and property. Risk management constitutes a system of decisions directed towards what needs to be done in order to reduce unacceptable risks. The problem of choice is in most cases based on economic analysis and every economic analysis is reduced to the question of the optimal utilization of financial resources. Thus, risk management itself is reduced to the problem of selecting risk reduction/elimination measures to bring about maximum risk reduction with the available means. The aim of this work is to study the risk management process of chlorine producing industrial facility for protection of the population and the environment from the consequences of storing hazardous substances. The Egyptian Petrochemical Factory which produces chlorine, located in Al-Ameriya Industrial zone near Alexandria, was to be a model for implementing risk management study.

Keywords: Risk Management, Safety, Emergency Preparedness

INTRODUCTION

The causes of naturally occurring events has not been understood, predicted or effectively prevented. In the meantime, there is a need to prepare ourselves to respond to these emergencies when and where they occur. While most industrial accidents can be contained within the boundaries of the industrials plant, there are those cases where impact extends beyond its boundaries to affect the plant neighborhood and have adverse short or long-term consequence affecting life, property, and society.

The extent of loss caused by such accidents depends on a large extent on the actions of the first responders to an emergency within the industrial facility and the local community around it.

The adequate response to such situations requires a well-coordinated action of individuals and institution from the local community. This can only be achieved if there were awareness in the community of the possible hazard and the need for mutual preparedness to cope with their consequences.

Review and Development of Legislation:

Legislation about safety at work and accident prevention exists in all countries. This legislation aims to protect primarily the workers in industry, but at the same time also to contribute to the safety of the population and the environment. Usually this legislation does not regulate in terms of risk, but may contain technical specifications, which sometimes require risk assessments to satisfy the authorities that the necessary margin of safety does exist.

In the last twenty years, however, this legislation has resulted in not being completely satisfactory. Therefore, a new type of legislation is being developed which is based on the probabilistic notion of risk and aims to reduce the risk of industrial activities.

Al-Ameriya was chosen to be a model for implementing the Risk Management Methodology as it contains 8 factories of different industrial type with various potential hazardous such as: the Egyptian Petrochemical Factory, Al-Ameriya Textile Factory, Gas Co., Sidi Kerrir and Alexandria Tire Factory. It is an industrial zone situated on the borders of Alexandria with residential areas and highway.

In addition, the residential areas found around this industrial zone are subjected to air pollution as a result of these factories emissions. Therefore, Al-Ameriya is considered an ideal location to implement the Risk Management Methodology as it needs awareness and preparedness plans to face the chemical accidents, which may result from these industrial factories. It is envisaged that implementation of the risk management methodology in Al-Ameriya will serve as a model for the establishment of plans for awareness and preparedness for emergencies at the local level, and may be replicated at other locations either at the local level or at the regional level.

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Objectives: The objectives of this study are stated as follows:

- To identify, assess, and quantify risks to the general public, to persons working in the area around the storage tanks, pipeline, production line, and operation and maintenance staff.
- To identify, assess and quantify risk arising from external situation, conditions and effects which could adversely affect the pipelines, and production line. Therefore, producing unacceptable levels of risk.
- To examine the ways in which the risk can reduce or eliminated.
- To recommend practical risk reduction measures for consideration in cost benefit background.
- To determine final levels of residual risks (assuming adoption/ implementation of the recommended risk reduction measures).

MATERIALS AND METHODS

Meteorological Data:

In addition to standard wind-rose information on wind speed and direction, the dispersion of release is dependent on the atmospheric stability or weather category. The available data should be analyzed. The detailed wind-rose data should be given and the overall proportions for day and night.

Populations:

In order to calculate the level of societal risk created by the different failure cases, a risk assessment requires information about the local population distribution. The populations are defined separately as day and night distribution for range buildings and locations.

The population group that are most exposed to potential releases are on-site and off-site, so the risk results will be most sensitive to the concerned facility population assumptions

Selected Company:

The field survey output of Al-Ameriya industrial zone showing that there are nine installations within the boundary of Al-Ameriya, the three companies that have the greatest potential hazards are:

- Petrochemical Company,
- Gasco Western Desert Gas Complex; and
- Sidpec Company.

We select the first company, the petrochemical Company.

Petrochemical Company:
General Information:

- The Egyptian Petrochemical Company is the sole petrochemical complex in Egypt.
- It was established in 1981.
- It is located in Al-Ameriya /Alexandria, on an Area of about 4 million m^2 of land.
- It was founded with an initial subscribed capital of.620 million L.E.
- The paid in capital currently stands at 513 million L.E..
- EPC's core business is the production, processing, treatment, marketing of the Petrochemicals and Intermediate Chemical Compounds.

Chlorine / Soda Plant:

The raw salt is brought by trucks and stock piled in the salt storage yard. Then it is carried to the hopper of the feed conveyer by the loaders. It is then fed to the salt saturation tank and dissolved the developed brine. It is pumped to the brine reactor, where barium / calcium chlorine is added in addition also 15% soda ash, 5% sodium sulfite. 1% precipitant and 20% caustic soda are added. Clean brine is pumped to the chelating resin tower to remove the remaining impurities is pumped to the electrolysis cell. While from the cathode compartment H_2 is generated, which is transferred to the H_2 compressors.

The 35% caustic solution product is accumulated into the catholyte receiver and then concentrated to 50%, part of latter is solidification, flaked and stored / bagged. Chlorine gas from electrolysis together with the recovered gas from the depleted brine is cooled, scrubbed dried in 2 towers by H_2SO_4, dried again to keep

water content below 30 PPM, compressed and sent to VCM plant. A part of Cl_2 is liquefied; H_2 is sent to caustic soda solidification where it is used as fuel, part is sent to HCL synthesis unit. Off gas from the different points treated with caustic soda to produce sodium hypo chlorite.

Risk Analysis of Chlorine:

Site Data Information:

Location	Al-Ameriya, Egypt
Building Air Exchanges Per Hour	0.43 (sheltered single storied)
Time:	July 31, 2003

Chemical Information:

Chemical Name:	Chlorine
Molecular Weight:	70.91 kg/kmol
TLV-TWA:	0.5 ppm
IDLH:	10 ppm
Footprint Level of Concern	10 ppm
Boiling Point	-29.25° F
Vapour Pressure at Ambient Temp	Greater than 1 atm
Ambient Saturation Concentration	1,000,000 ppm or 100.0%

Atmospheric Information: (Manual Input of Data):

Wind:	2 meters/sec from NE at 3 meters
Stability Class:	E
Air Temperature:	30° C
Relative Humidity	80%
Ground Roughness:	Urban or forest

Results:

This dispersion model used to estimate the distance from the release of chlorine gas is called ALOH:

- ALOHA stands for Areal Location of Hazardous atmospheres.
- ALOHA is an Air Dispersion model to evaluate HS release scenarios and predict dispersion.

- Estimates impacts distances from release of HS using toxicological and physical properties of released chemical.
- Using real-time conditions.
- Plots the predicated affected area as shown in the figure footprint, as well as concentrations at important location.
- Provides estimates, not only precise answers.
- ALOHA is used not only to estimate the extent of the area that could be at risk in an incident (that is the footprint) but also to obtain predicated indoor and outdoor concentrations at any location of special concern during the hour after a release begins.
- ALOHA displays graph of predicated chlorine concentrations at specified points during the hour after the release begins. The horizontal axis of the graph represents time (from 0 to 60 minutes), at the vertical axis represents concentrations at the locations. Three lines are visible, on this graph; the solid red line represents the predicated outdoor, ground level concentrations. The dashed blue line represents predicated concentration inside a building selected.

Source Strength Information:

Leak from short pipe or valve in horizontal cylindrical tank.
The chemical escaped from the tank as a gas.

Tank Diameter:	2.8 meters
Tank Length:	5.25 meters
Tank Volume	32300 liters Tank contains liquid
Internal Temperate	30° C

Chemical Mass in Tank:	30 tons
Tank is	60% full
Circular Opening Diameter	4 inches
Opening	2.8 meters from tank bottom
Release Duration	17 minutes
Max Computed Release Rate	2,170 pounds/min
Max Average Sustained Release Rate	1,980 pounds/min (averaged over a minute or more)
Total Amount Released:	12,000 pounds

Footprint Information:

Model Run	Heavy Gas
User-specified LOC	Equals IDLH (10 ppm)
Max Threat Zone for LOC	2.9 miles

Time Dependent Information:

Indoor graph is shown with a dotted line.	
Concentration estimates at the point:	Max Concentration:
Downwind: 1 meters	Outdoor: 278,000 ppm
Off Centerline: 1 meters	Indoor: 30,900 ppm
Concentration/Dose Estimates at the point:	Max Concentration:
Downwind: 100 meters	Outdoor: 235 ppm
Off Centerline: 100 meters	Indoor: 2.22 ppm
Dose Estimates at the point:	Max Dose:(in the first hour)
Downwind: 100 meters	Outdoor: 316 ppm-min
Off Centerline: 100 meters	Indoor: 108 ppm-min

The model predicated that the cloud of chlorine covered an area where chemical concentration in the air became high enough to pose a hazard to people as shown in Figure 1, this diagram is called cloud's footprint.

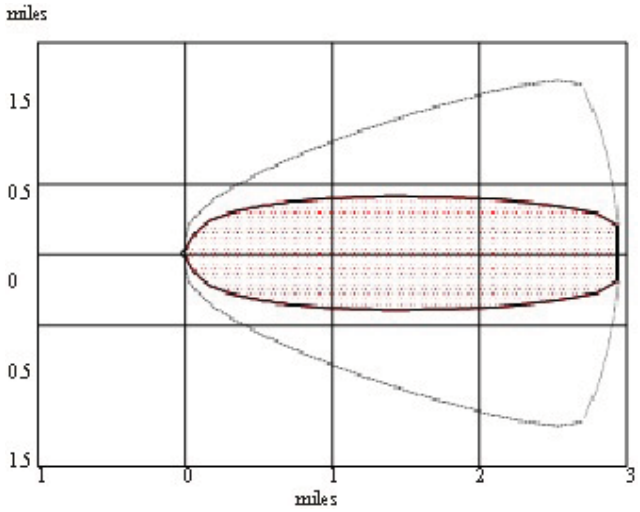

Fig. 1: Foot Print-Max Threat Zone

Checking concentration at a Location of Concern:

- The model predicts the outdoors concentration that exceeds the Level of Concern (LOC) and in this case LOC is considered the Immediately Dangerous for Life and Health (IDLH) that intended to represent hazard to healthy adults.
- As shown in Figure 2, this a point located at (0,0) i.e. the concentration at the source of release the Y axis represents the concentration at the location up to 266,000 ppm outdoor and 34,700 ppm indoor.

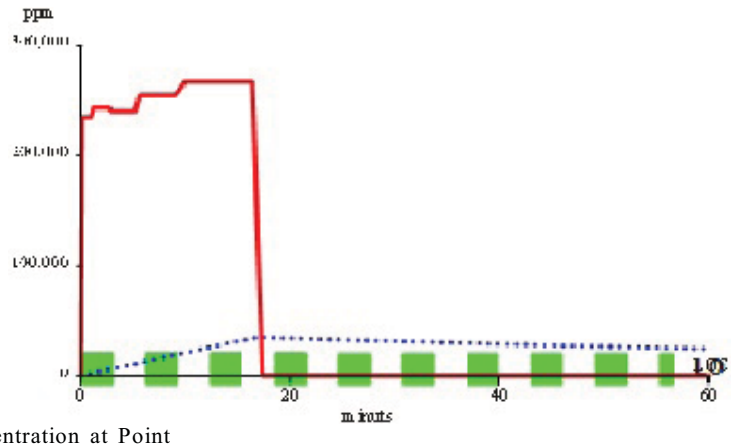

Fig. 2: Max. Concentration at Point

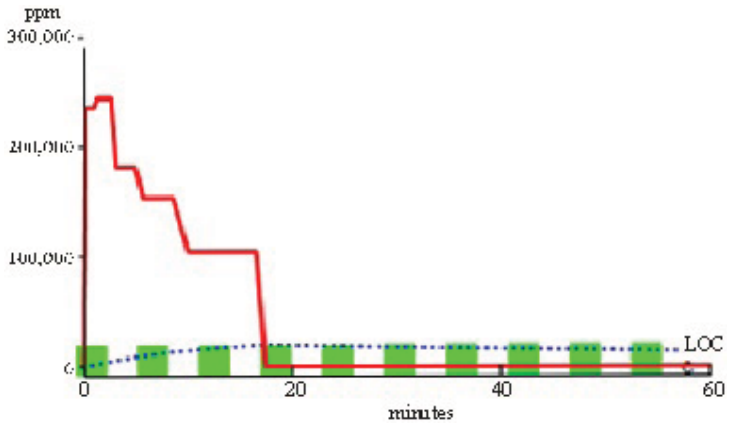

Fig. 3: Max. Concentration at Point

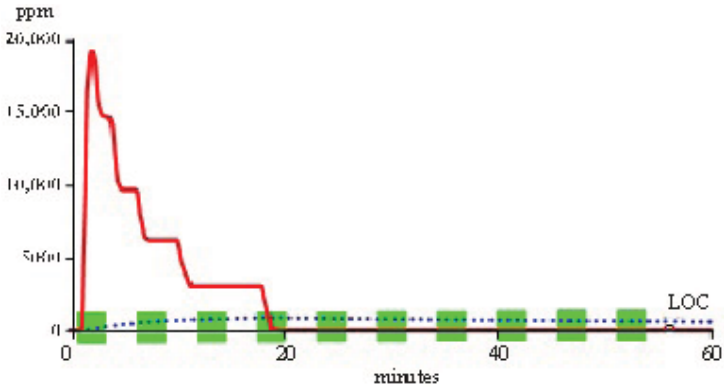

Fig. 4: Max. Concentration at Point

- Figure 3 shows that the cloud of chlorine would arrive to the point located at 10 meter downwind of the container in about 1 minute.
- Figure 4 shows that the cloud concentration up to 19,200 ppm outdoor and indoors up to 921 ppm at a location point 100 meter downwind. The cloud concentration up 206 ppm outdoor and 16.6 ppm indoor in about 8 minutes as shown in Figure 5 at location 1000 meter downwind. The cloud concentration at location 2500 meter downwind is 36.9 ppm outdoor and 3.83 ppm indoor in about 14 minutes as shown in Figure 6. The cloud concentration at location 5000 meter downwind is 10 ppm outdoor and 1.3 ppm

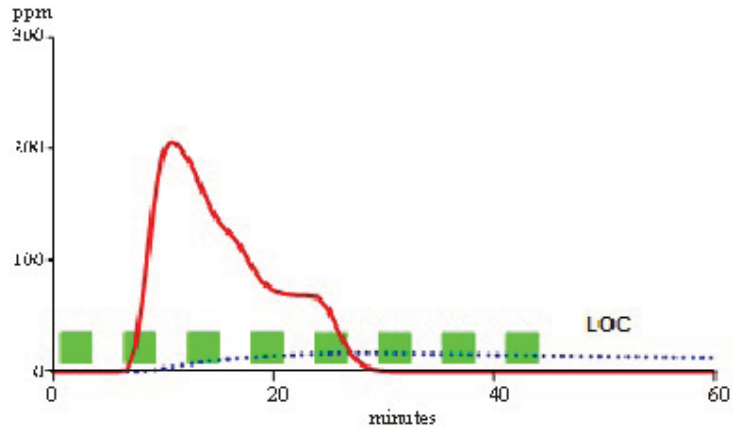

Fig. 5: Max. Concentration at Point X1000, Y0 m.

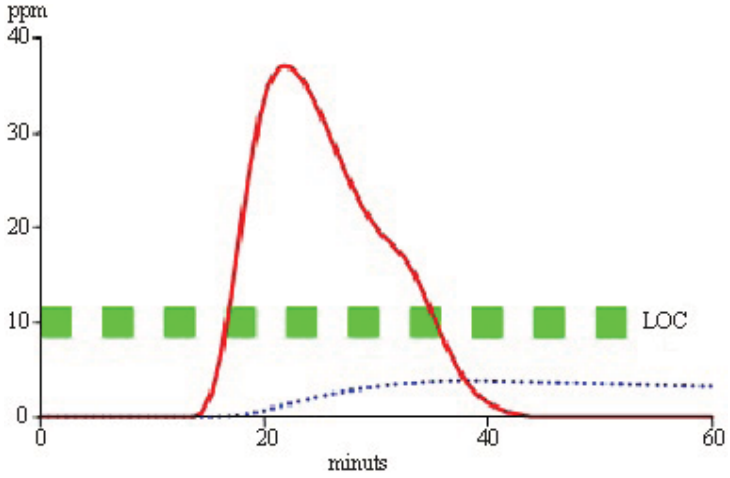

Fig. 6: Max. Concentration at Point X2500, Y0 m.

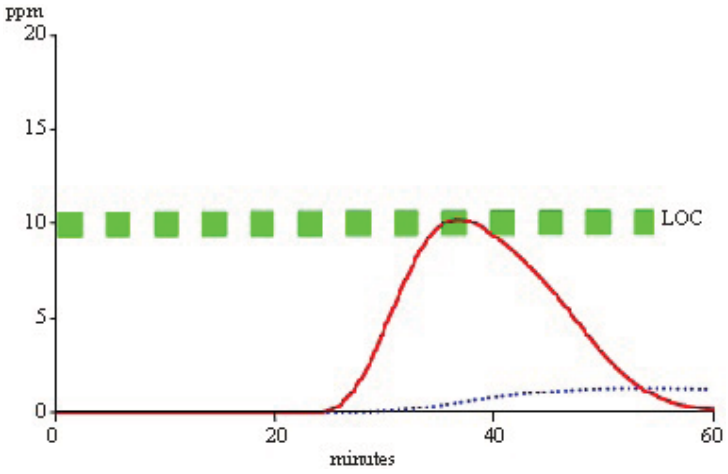

Fig. 7: Max. Concentration at Point X5000, Y0 m.

indoor in about 26 minutes as shown in Figure 7. The cloud concentration at location 100 meter at X-axis and 100 at Y-axis is 584 ppm outdoor and 6.65 ppm indoor in about 2 minutes as shown in Figure 8.

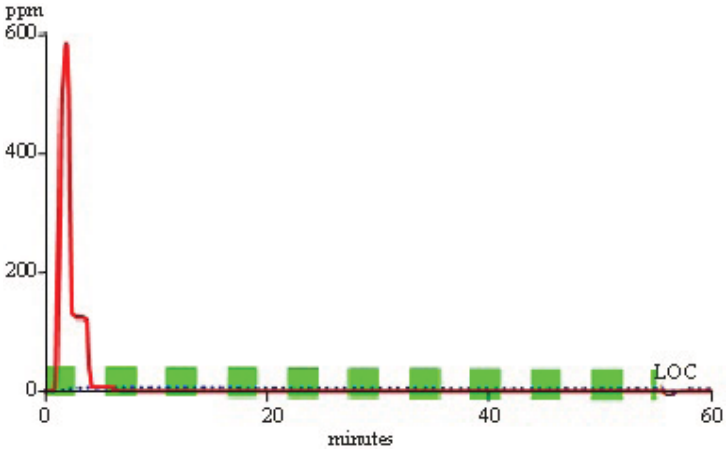

Fig. 8: Max. Concentration at Point X100,

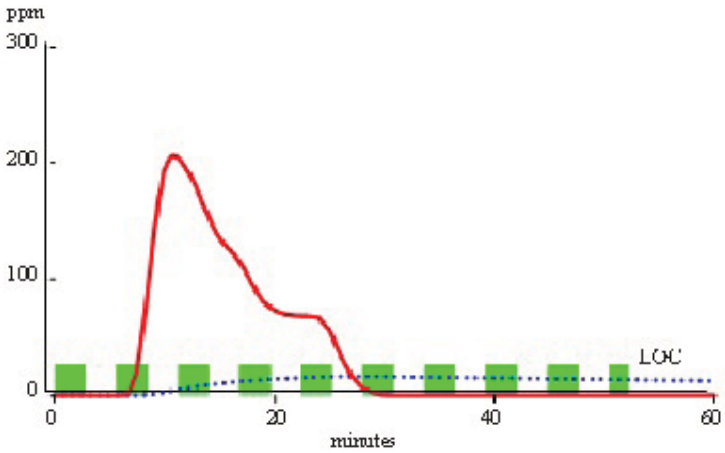

Fig. 9: Max. Concentration at Point X1000, Y10 m.

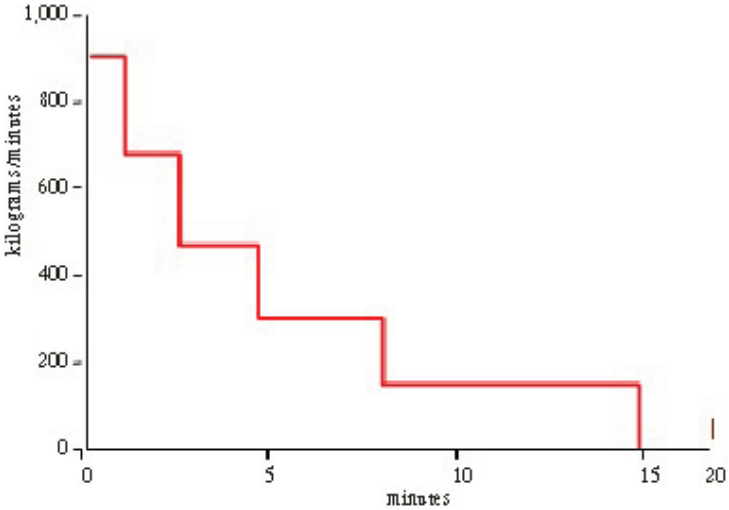

Fig. 10: Source Strength of the Release

The cloud concentration at location 1000 meter downwind and 10 meter off centerline is 206 ppm outdoor and 16.6 ppm indoor in about 6minutes as shown in Figure 9.

- The graph shows the predicated average release rate during the hour after the release begins. On the graph time since the release started (from 0 to 17 minutes) is shown on the horizontal axis and the release rate is shown on the vertical axis. Since the chlorine is escaped from a pressurized container the model predicts that release rate stats out high, then declines as container pressure drops. The highest step on the graph is the Maximum Average Sustained Release Rate as shown in Figure 10.
- The dispersion model foot print results were mapped to a geographical map of Al-Ameriya industrial zone with the chlorine plant as the center of the foot print to show the area due affected the release of chlorine.

Studying the case of Chlorine release from petrochemical company and applying the computer model to determine the affected area according to the wind velocity and direction.

El-Amreya Industrial Zone:
Chemical:
ID: BRZ02Z
Name: Chlorine
CAS number: 7782-50-5
Molecular weight: 70.906g/g-mole
Boiling point: 239.1 K
Ceiling: 1.45 mg/m^3
IDLH: 29.5mg/m^3
Toxic endpoint: 8.7mg/m^3
ERPG1: 1mg/m^3
ERPG2: 3mg/m^3
ERPG3: 20mg/m^3

Release:
Source type: Evaporating pool
Release type: Continuous
Emission rate: 1.0kg/s
Source area: 0.0125m^2

Output:
Height of interest: 1.6 meters
Averaging time: 3600.0seconds
Lower contour: 29.5mg/m^3
Middle contour: 500mg/m^3
Upper contour: 5000mg/m^3

Chlorine:
Slab Summary:
Meteorology:
Wind speed: 2.5 m/s
Anemometer height: 10.0 meters
Surface roughness: 0.03 meters
Stability option: stability class
Stability class: 6 (F)

Results:

Concentration: Distance		
Mg/m^3		Kilometers
29.5 (IDLH)	steady-state	5.006
500	steady-state	0.742
5000	steady-state	0.060

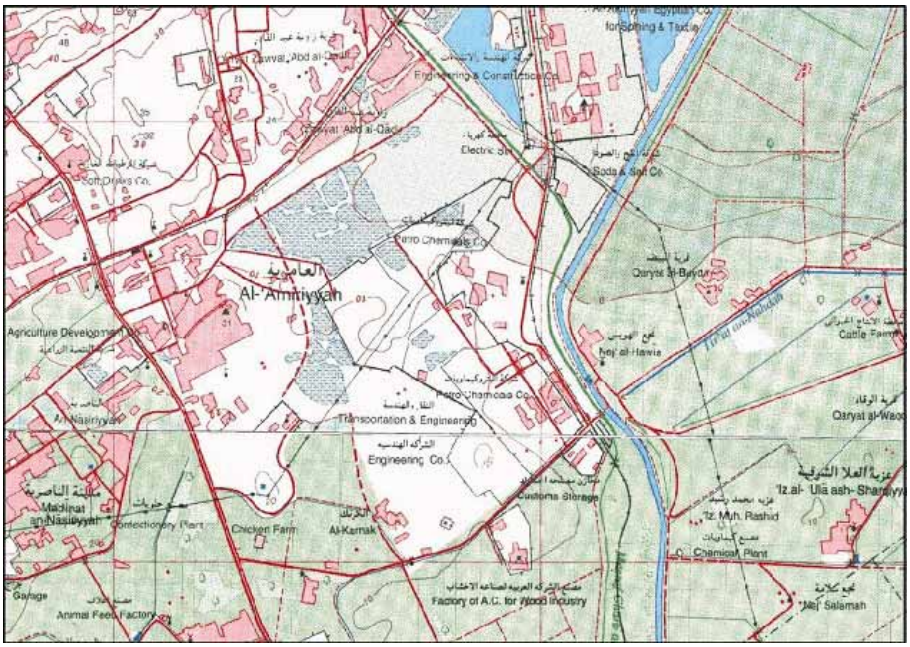

Fig. : El-Amreya Industrial Zone

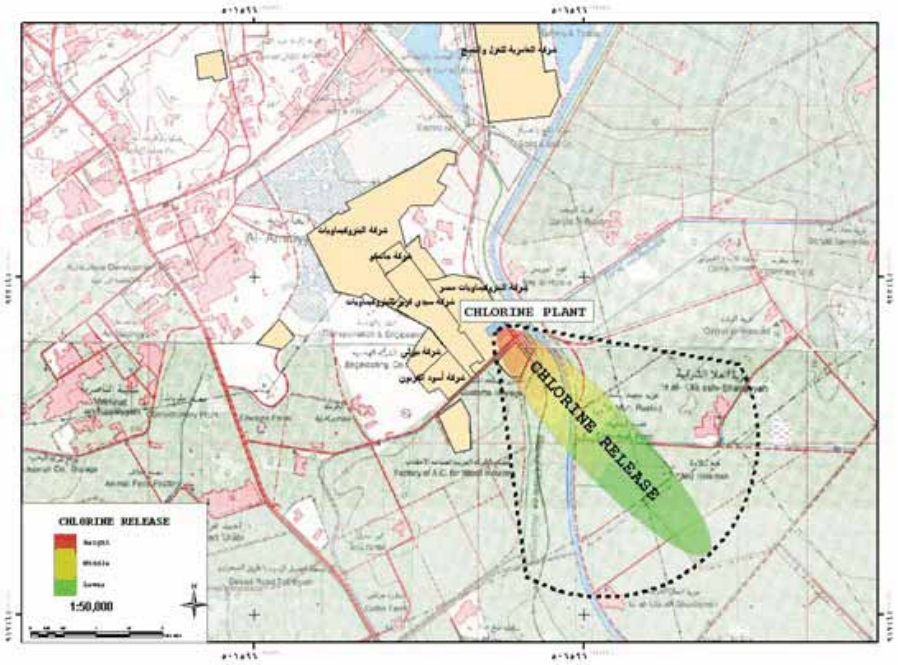

Fig. 11:

- The Slab Model is used; Slab Model is a computer model that stimulates the atmospheric dispersion of denser-than-air release.
- Atmospheric desperation of release is calculated by solving the conservation equations of release is calculated by solving the conservation equations of mass, momentum, energy and species. A cloud from a dense gas release behaves very differently than a plume from a lighter than air release.

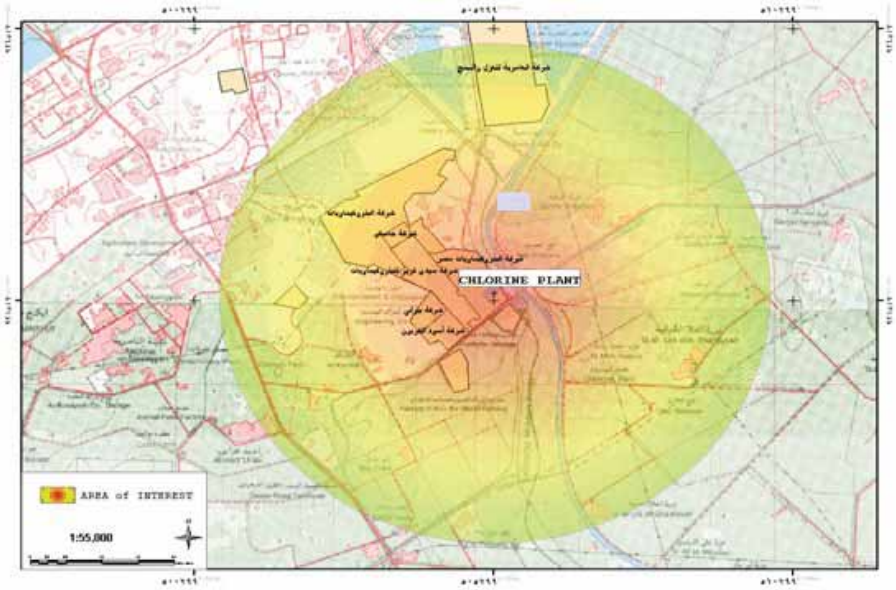

Fig. 12:

- Figure 11 shows the concentration (ppm or mg/m3) versus downwind distances. The Y-axis representing the concentration and the X-axis representing the downwind distance.
- Figure 12: shows the concentration of release at different distances, according to the selected concentration point.

Final Recommendations:

- Ensure systematic improvement and updating of databases on hazardous substances especially hazard identification.
- Provide additional insight into the safety status of those facilities and storages, which have been identified by risk assessment methodology as potentially significant risk resources for public health and environment.
- Apply risk assessment methodology for risk assessment in transportation of hazardous substances.
- For acceptability criteria of technology risks, discuss in more detail and within the environmental protection regulation, and adopt values for socially acceptable risks through issuing the risk profile for each facility.
- Start as soon as possible with creating a database about industrial accidents that has occurred in Egypt.
- Continue with all those activities, which in accordance with international recommendations contribute to increased safety and reliability of industrial facilities operation.
- Develop the national risk profile.

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