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INDUSTRIAL RISK ASSESSMENT AROUND PENTANE STORAGE TANK IN HASSI R'MEL CITY ALGERIA, USING AREAL LOCATIONS OF HAZARDOUS ATMOSPHERES (ALOHA) SOFTWARE

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ABSTRACT

This study aims to determine the maximum extent of pollution, caused by the leakage of Pentane from a storage tank within the transport and storage center (CSTF), located in HassiR'mel city Laghouat province Algeria; To achieve the desired results, we relied on ALOHA® v. 5.4.7 software (Areal Locations of Hazardous Atmospheres) for accidents simulation, and Google Earth as an output tool to show results on the city map. The results prove that the city of HassiR'Mel is almost completely threatened by thermal effects resulting from a BLEVE phenomenon, which can reach a distance of 2.3 kilometers.

KEY WORDS: Pollution, Pentane, Risk assessment, ALOHA, HassiR'mel

INTRODUCTION

Industrial activity is one of the most connected activities to the city, even is due to it evolution that the city appears in the current form (Meyronin, 2003); Seveso, 1976; Bhopal, 1984 Tchernoby, l1986, Fukushima, 2011 Accidents that set a new face to the relationship between the city and the industrial activity, a less attractive and a bloodier face so this activity which was a wealth creator, become a risk creator at the same time (Beck, 2001), that double the challenge of finding the appropriate location for industrial activity this time in terms of security resulting the appearance of studies that aim to study the risk assessment, risk prevention and vulnerability.

Algerian economy is primarily focused on oil and gas industry. This industry represents the main hotspot of the national economy (Benramdane, 2017), and accounted for 98% of national exports in the 2000s (Talahite, 2012). The oil and gas industry in Algeria is based on extraction and processing from the Hassi Messaoud field in Ouragla province and HassiR'Mel field in Laghouat province respectively the main sources of oil and gas.

Resulting from the 1984 administrative reform (Sofrani and *et al.*, 2019), HassiR'mel is one of the most important industrial areas in Algeria based on the massive gas reserves it holds. The HassiR'Mel gas field discovery caused a regional attraction to the city as it became a magnet for well-paid permanent job seekers. As a result, the city' s population grew rapidly due to migration from the entire country to HassiR'Mel thus rendering the city's urbanization chaotic and unorganized, resulting in some parts of the residential areas being in the CSTF threat zone. The aim of this research isto determine the maximum extent of pollution, caused by the leakage of Pentane from a storage tank within the CSTF using ALOHA software.

ALOHA is a software developed by the National Oceanic and Atmospheric Administration (NOAA) in collaboration with the Environmental Protection Agency (EPA) Office of Emergency Management (NOAA, 2013). It helps assess - in emergency situations - the atmospheric dispersion of released chemicals, as it takes into account the pollutant's toxicological and physical properties, and the site characteristics (INERIS, 2006)

MATERIALS AND METHOD

Study area

The city of HassiR'Mel is located in the extreme south of Laghouat province, at 520 km from the capital Algiers. It is situated between latitude 32° 90 North-East and longitude 3°271 East, with an estimated surface area of 2841 km², (Figure 3). Discovered in 1956 by the French Company of Algerian Petroleum, the HassiR'Mel field is one of the most important gas fields in the world (Bisson, 1983). The facilities built around HassiR'Mel are the backbone of the Algerian gas industry.

The storage and transfer center was established in 1978 to store the output of various industrial units located in the municipality. The storage area consists of 7 floating roof tanks for condensation with a total storage capacity of 227,000 m³ and 12 LPG storage spheres with a capacity of 7,170 m² each, for a total storage capacity of 78,000 m³.

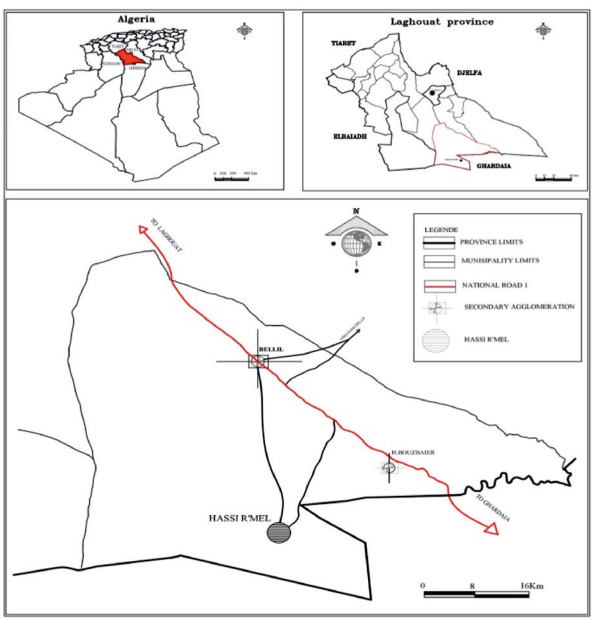


Fig. 1. storage and transfer center (CSTF)

Materials

To attain the intended results, we used the software ALOHA® v. 5.4.7 to simulate incidents, and Google Earth as an output tool to display the results on the city map. For the climatic data, we based on the data recorded in the meteorological station of HassiR'Mel airport. For the storage area features and the nature of the stored materials, we based on the storage and transfer center hazard study (*Etude de danger unité CSTF rapport numero EP002718 n 6-3.*, Sonatrach., 2010), and (Hassani *et al.*, 2018)

Method

As urban actors, we are concerned with determining the maximum extent of damage possible. The simulation in this case is a mapping of exposed areas for an industrial accident that may cause a disastrous malfunction in the LPG storage sphere, regardless of the cause. Therefore, the deterministic approach is followed, considering the highest threats of an industrial accident independent of its potential (Propeck-Zimmermann *et al.*, 2007)

Scenarios description

In the case of pentane storage tank catastrophic failure, ALOHA software allows the possibility of simulating three types of accidents

Leaking tank, chemical is not burning as it escapes into the atmosphere: When chemical is not burning as it escapes into the atmosphere, ALOHA software allows the possibility of simulating three scenarios; Vapor cloud toxic area; Flammable area of vapor cloud and blast area of vapor cloud explosion.

Leaking tank, chemical is burning as a jet fire: A jet fire occurs when a flammable liquid or gas ignites as a jet after being released from a pressurized, punctured container or pipe (Gopalaswami *et al.*, 2016).

BLEVE, tank explodes and chemical burns in a fireball: Boiling Liquid Expanding Vapor Explosion (BLEVE) is defined by the Center for Chemical Process Safety as a sudden release of a large mass of

Locationinformation	Building type	Chemical information	Atmospheric options	Sourceinformation
Elevation 760 m Latitude 32°57′17" N Longitude 3°16′30"E	Single storied building Open country	- Pure chemicals Molecular weight 44.10 g/mol Ambient boiling point -44.2° F Freezing point -305.8° F	- Wind speed 15 miles/h - Wind from West at 10 meters - Air temperature 40° c - Humidity 25 %	-floating roof storage tank - Diameter 61 m - Volume 450000 m³ - The mass 30078 tons -liquid level 100%

Fig. 2. basic data fed into ALOHA model

superheated liquid under pressure into the atmosphere (*Guidelines for consequence analysis of chemical releases*, 2019), (CCPS., 2018)

This simulation was performed under 05 main scenarios based on the input shown in Figure 2.

RESULTS

Leaking tank, chemical is not burning as it escapes into the atmosphere:

Toxic area of vapor cloud

Toxic area of vapor cloud threat zones is represented in Table 1 and Figures 3 and 4.

Table 1. Toxic area of vapor cloud

The threshold	Threat zone (m)	concentration
200000 ppm	261	AEGL-3(60 min)
33000 ppm	554	AEGL-2(60 min)
3000 ppm	1800	AEGL-1(60 min)

Flammable area of vapor cloud:

Flammable area of vapor cloud threat zones is represented in Table 2 and Figures 5 and 6.

Table 2. Flammable area of vapor cloud

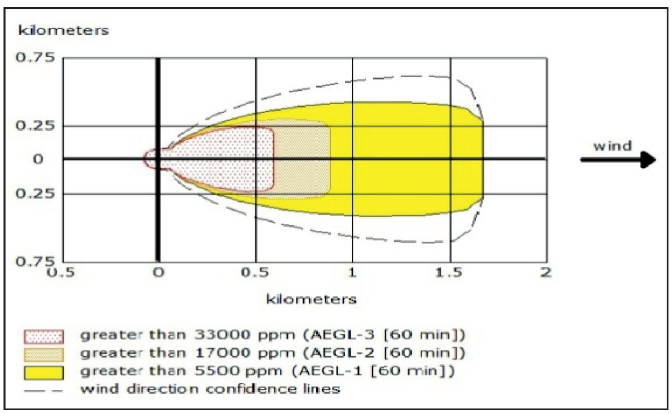
The threshold	Threat zone (Km)	Effects
8400 ppm	1.1	60% LEL = flame pockets
1400 ppm	2.7	10% LEL

Blast area of vapor cloud explosion:

Blast area of vapor cloud explosion threat zones are represented in Table 3 and Figures 7 and 8.

Table 3. Blast area of vapor cloud explosion

The threshold	Threat zone (m)	Effects
3.5 psi	843	serious injury likely
1.0 psi	1100	shatters glass



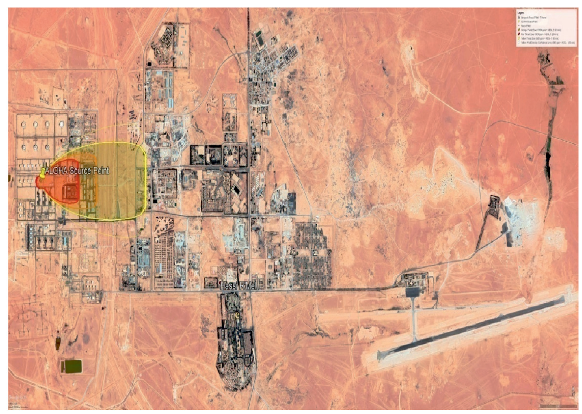
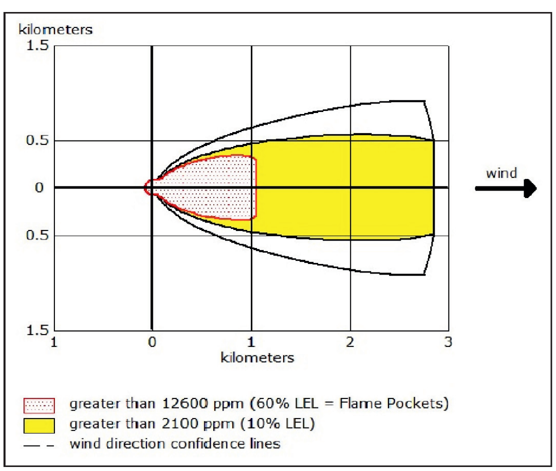


Fig. 3 and 4. Toxic area of vapor cloud Threat zones
Source: Simulation result show on Google Earth Pro



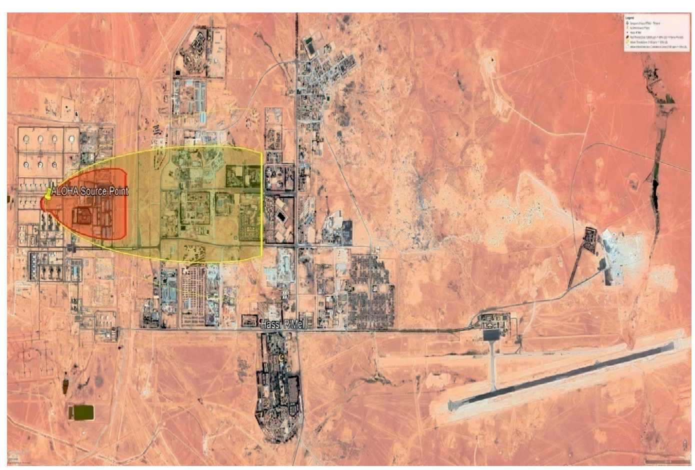
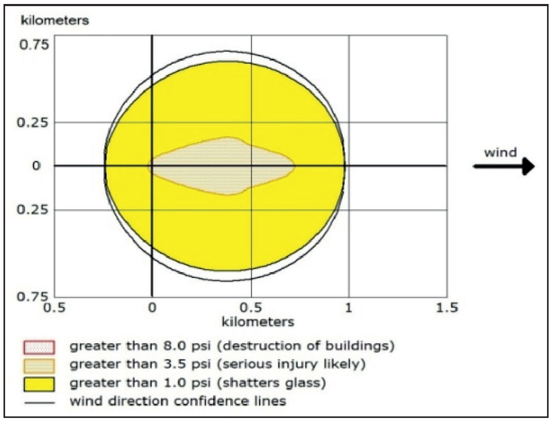


Fig. 5 and 6. Flammable area of vapor cloud
Source: Simulation result show on Google Earth Pro



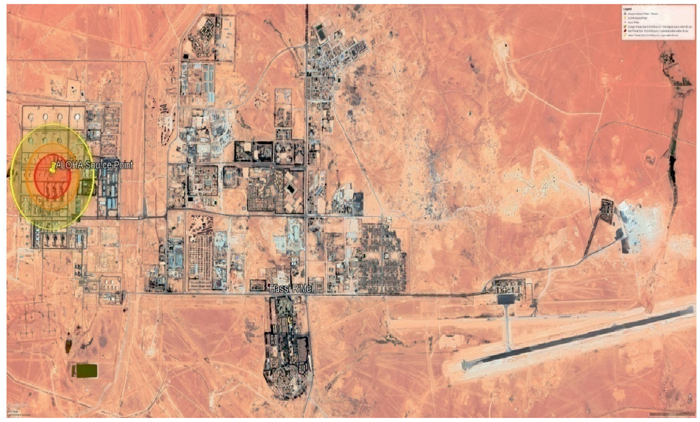


Fig. 7 and 8. Blast area of vapor cloud explosion
Source: Simulation result show on Google Earth Pro

Table 4. thermal radiation effect zones due to jet fire

The threshold	Threat zone (m)	Effects
Greater than 10.0 KW/ (sq m)	213	Potentially lethal within 60sec
Greater than 5.0 KW/ (sq m)	353	2 nd degree burns within 60sec
Greater than 2.0 KW/ (sq m)	583	Pain within 60sec

Leaking tank, chemical is burning as a jet fire

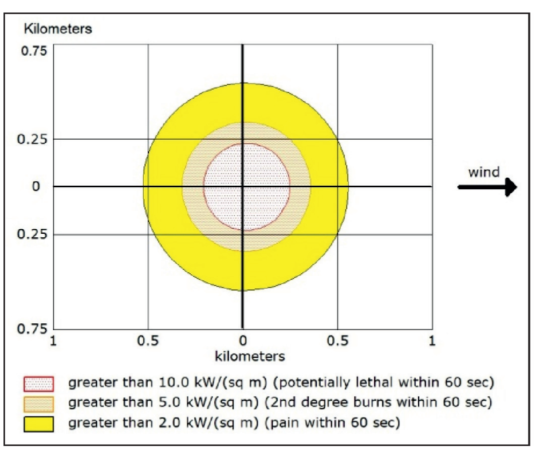
Thermal radiation effect zones due to jet fire in HassiR'Mel city are represented in Table 4 and Figures 9 and 10

BLEVE, tank explodes and chemical burns in a fireball

For our study case, results are shown in Table 5 and Figures 11 and 12.

Table 5. Thermal radiation threat zones resulting from a BLEVE

The threshold	Threat zone (Km)	Fireball diameter (m)	Burn duration	Effects
Greater than 10.0 KW/ (sq m)	1.1	507	26 sec	Potentially lethal within 60sec
Greater than 5.0 KW/ (sq m)	1.5			2 nd degree burns within 60sec
Greater than 2.0 KW/ (sq m)	2.3			Pain within 60sec



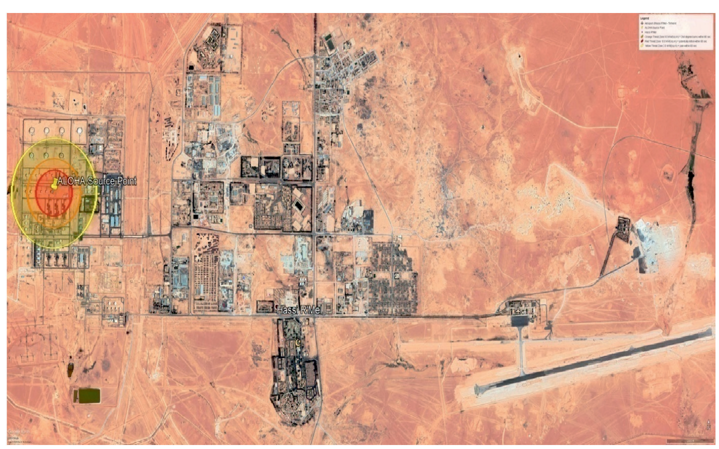
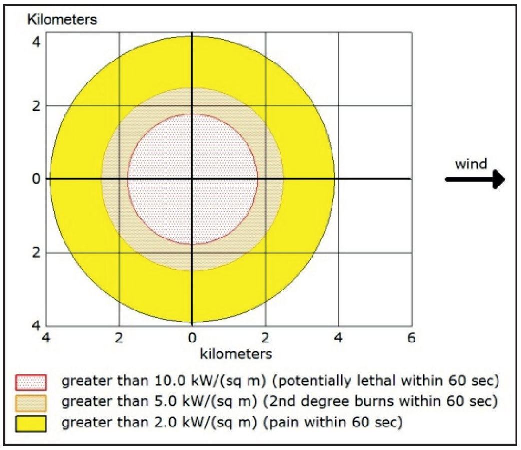


Fig. 9 and 10. Blast area of vapor cloud explosion
Source: Simulation result show on Google Earth Pro



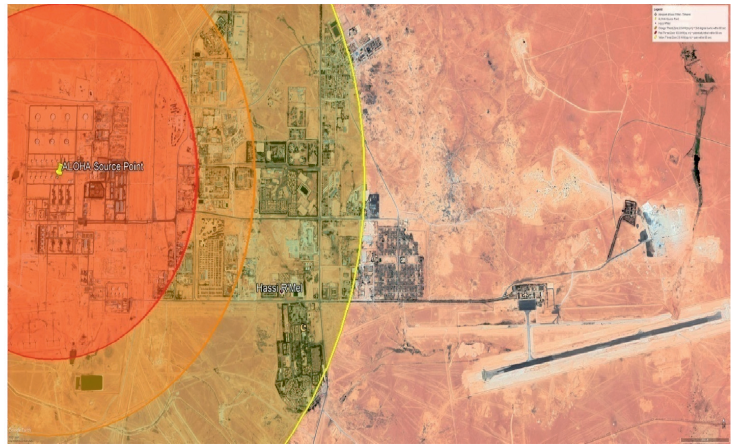


Fig. 11 and 12. thermal radiation threat zones
Source: Simulation result show on Google Earth Pro

DISCUSSION AND CONCLUSION

Through the simulation that was done of the five possible scenarios, we have made sure that the city is within the threat zone, and so the lives and property safety of the residents are threatened daily.

For toxic area of vapor cloud spread zone, it differs depending on concentration of the chemical leaked in the air defined by ALOHA in parts per million (ppm), The damage varies according to the Acute exposure guideline levels AEGL, in our simulation toxic area of vapor cloud threat zone can reach a range of 1,800 meters for 3000 ppm.

The Flammable area of vapor cloud can reach 2.7 kilometers, which includes the central western part of HassiR'Mel city.

Based on the obtained results, it appears clearly that in the case of a stored material leakage without the presence of an ignition source, three factors constitute the main role in the definition of the threatened zones:

- The volume and chemical properties of the stored material.
- Climatic characteristics of the area (temperature, wind speed and direction).
- The exposure time to effects resulting from a leak, which represents the limit point of damage that can be inflicted on humans, which is consistent with the results of (Anjana *et al.*, 2018).

Thermal effects resulting from a BLEVE phenomenon is considered the biggest and most threatening of the city's population, as the threat zone of 10kw/m² thermal effect extend to 1100 meters, which is the death threat if a person is exposed to this heat effect for more than 60 seconds; for the thermal effect of 5.0kw/m², the threat zone can reach 1500 m, where exposure to this thermal effect for more than 60 seconds poses a risk of second-degree burns. For the thermal effect of 2.0kw/m² the threat zone can reach 2300 m.

RECOMMENDATIONS

This study aims to determine the maximum extent of pollution, caused by the leakage of Pentane from a storage tank within the (CSTF), located in HassiR'mel city Laghouat province Algeria. Based on the results presented in this paper, we recommend that city officials build windbreaks, both natural (trees) and artificial, in order to reduce wind speed and change its direction, especially for western winds.

On the other hand, it is advised that the storage and transfer center managers avoid using the total storage capacity of the LPG storage spheres, and only use the 75% limit for each sphere in order to reduce the extent of damage in case of an accident. We advise city planners that the heated LPG storage equipment similar to the one we studied should be at a distance of not less than 03 km from the urban area.

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