Study Of Impact Of Terrain Structure On The Dispersion Of Accidentally Released Air Pollutants

Sk. Moumita Manjur[1], Sidney Lin[1]

[1]Lamar University, Beaumont, TX, U.S.A.

Abstract

Toxic and hazardous air pollutants are released during chemical processes. The surrounding area of a chemical facility always has a high risk of air pollution by released chemicals. Furthermore, the personnel of the facility as well as community residents have risks of sudden catastrophic exposure into toxic chemicals in case of an unplanned/accidental chemical release. Exposure to high concentration of toxic chemicals may cause serious health hazard and even death depending on the level of toxicity and severity of the chemical release condition. In the situation of an accidental release, emergency response and evacuation plan should be efficiently prepared and implied to minimize the dire consequence. Additionally, chronic exposure to a hazardous chemical of a concentration higher than the permissible limit causes slow development of serious health problems. Unpermitted release should also be addressed and minimized to ensure safer and sustainable environment. A mathematical simulation can provide comprehensive understanding about the dispersion trend of a chemical depending on its properties, ambient condition, and surrounding terrain structure. A proper planning for reduction of pollution along with efficient emergency response and rescue action plan can be developed based on the understanding from mathematical simulation.

A finite element analysis model of a released toxic chemical from an industrial process unit into surrounding ambience has been developed using COMSOL Multiphysics 6.2. The developed high resolution model suggests the precise and comprehensive calculations over small elements as the whole domain geometry is discretized into a number of small elements. Different scenarios in terms of terrain structure such as unobstructed, slightly obstructed, and complexly obstructed terrains have been considered to study the dispersion trend. The diffusion and convection of the released chemical through ambient air is the prevailing driving mechanism of transport. The dispersion trend has been estimated by Fick's 2nd law of diffusion integrated with convection by velocity field of air. Different wind speeds and directions have been applied to observe effect of wind on the chemical dispersion. Velocity field for the wind speed was established on the principle of compressible form of the Navier-Stokes and continuity equations. Transport and thermodynamic properties of air and chemical species are estimated at different temperatures and pressures. The impact of humidity level was also investigated in this work. The calculated results are analyzed to study impacts of wind speed, ambient temperature and humidity and terrain type on the propagation of chemical species over time.

Reference

Hongjun Zhu & Jiaqiang Jing, Numerical Simulation of Gas Leaking Diffusion from Storage Tank, Communications in computer and information science, Vol. ICICIS 2011, pp. 416 – 421, 2011
Fiorucci et al,Risk Assessment of Dangerous Products Release and Dispersion: a Comparison Between CFD and Integral Models. Chemical Engineering Transactions, vol.13, pp195–200, 2008

Figures used in the abstract

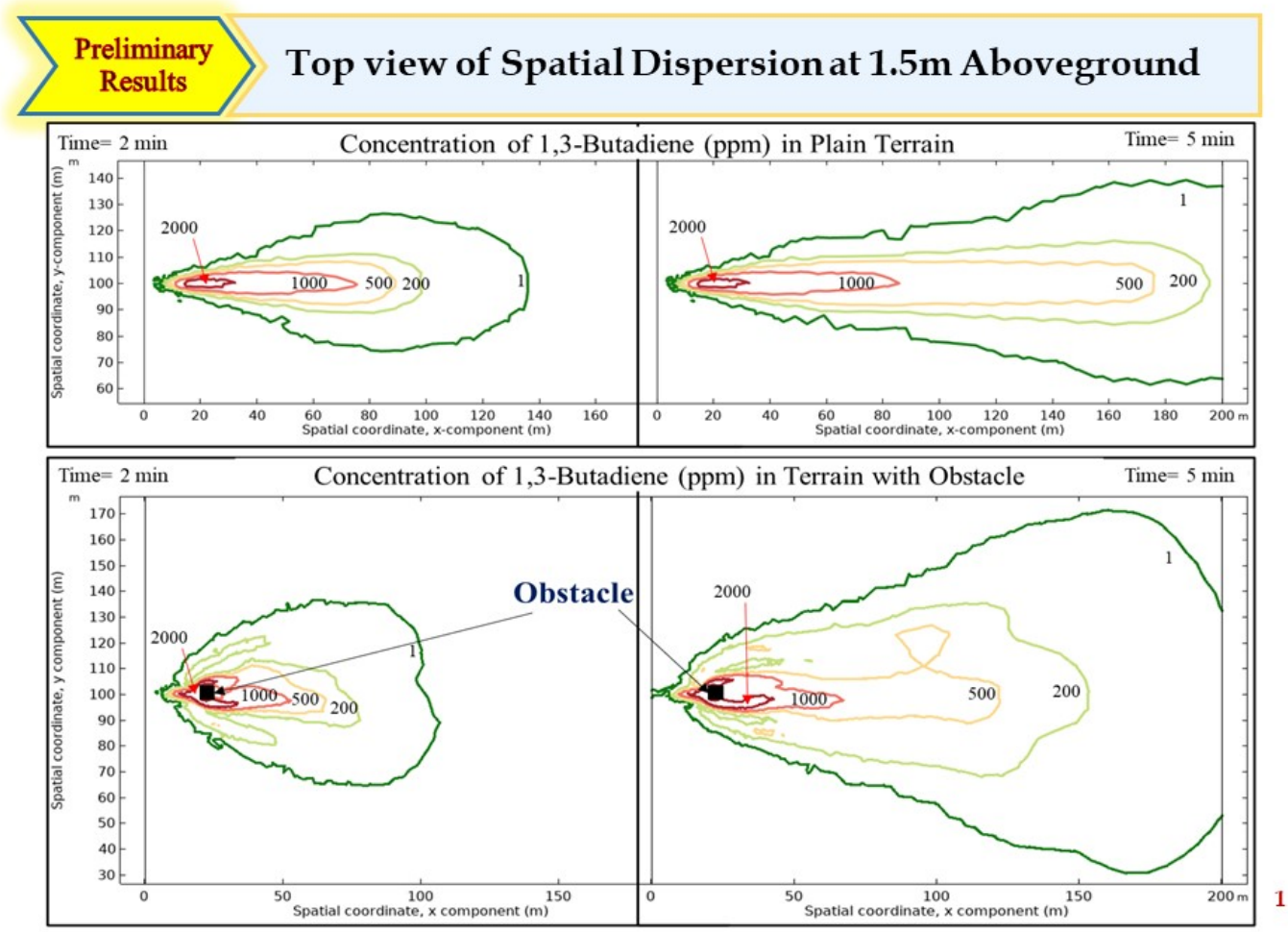

Figure 1 : Top view of spatial dispersion of 1,3-Butadiene 1.5 m above ground under different terrain structures.

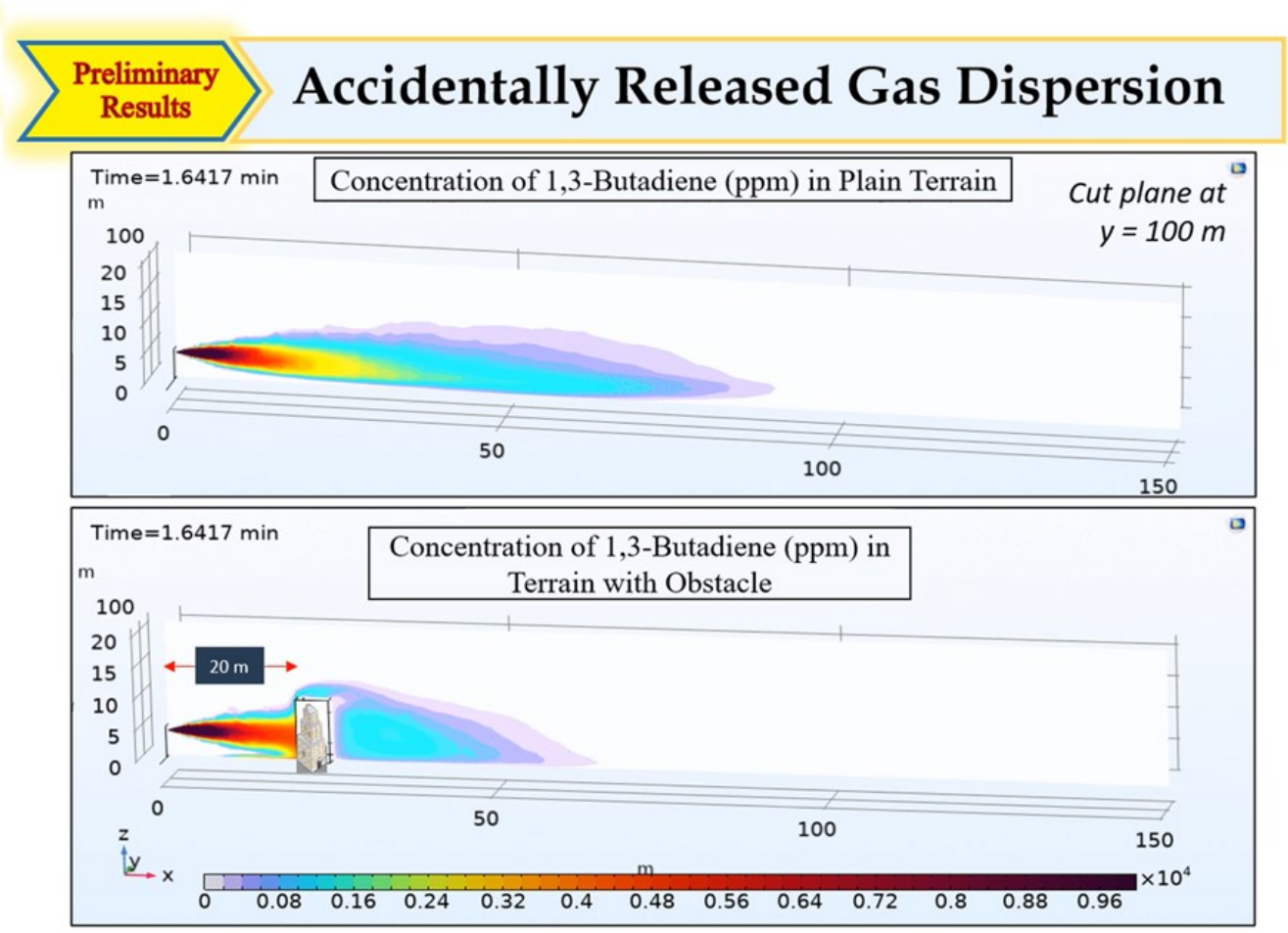

Figure 2 : Time dependent concentration profiles of accidentally released 1,3-Butadiene under different terrain structures.