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Utilizing Wind Rose Information for the Prediction of Ammonia Migration

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Abstract
Exposure to high concentrations of ammonia can be harmful to human health. Ammonia is a strong irritant and can cause respiratory problems, such as coughing, wheezing, and shortness of breath. Prolonged exposure to high concentrations of ammonia can also cause damage to the lungs, and in severe cases, can lead to death. In addition to respiratory effects, ammonia exposure can also cause eye, nose and throat irritation, skin rashes and other symptoms. At high concentrations, ammonia can also cause chemical burns to the skin and eyes. The severity of the health effects will depend on the concentration of ammonia, the duration of exposure, and the specific characteristics of the individual exposed, such as their age, health, and any pre-existing respiratory condition. Wind can affect the migration of ammonia by influencing the dispersion and diffusion of the gas. Strong winds can disperse ammonia over a wide area, reducing the concentration in any one location. Conversely, calm winds can cause ammonia to accumulate in a specific area, leading to higher concentrations. The direction and strength of the wind can also affect the direction of ammonia migration, potentially carrying the gas towards or away from sensitive areas such as residential neighbourhoods or wildlife habitats. A wind rose is a graphical representation of the distribution of wind speeds and directions at a specific location. It is often used to understand the dominant wind patterns and how they may influence the dispersion of pollutants such as ammonia. The direction from which the wind is blowing is represented on the outer circle, with the wind speed represented on the inner circles. When it comes to ammonia dispersion, the wind rose can be used to understand how the dominant wind patterns in a specific location may influence the spread

of ammonia emissions. For example, if the wind rose shows that the dominant winds are blowing from the direction of an ammonia source, such as a fertilizer plant, towards a sensitive receptor, such as a residential area, it can be an indication that the ammonia emissions from the source may pose a higher risk to the residents living in the area. Additionally, the wind rose can also be used to understand how the wind patterns may influence the dispersion of ammonia emissions within the atmosphere. If the wind rose shows that the dominant winds are blowing in a specific direction, it can indicate how the ammonia emissions will be transported and dispersed in the atmosphere. In summary, the wind rose is an important tool for understanding the wind patterns in a specific location and how they may influence the dispersion of ammonia emissions. It can be used to assess the potential risks associated with ammonia emissions and to make recommendations for controlling or mitigating ammonia migration strategies.
Keywords: Ammonia, Wind Rose, Dispersion

Introduction

Ammonia refers to a colourless gas with a characteristic pungent smell which dissolves in water to give a strongly alkaline solution (Yarandi et al. 2021). In facts, the ammonia leaks can cause significant harm to human health and the environment, and that is why it is important to be concerned about them. According to Anjana et al (2018) some reasons why ammonia leaks are a concern include:

1. Ammonia is a toxic chemical that can cause severe respiratory problems and other health effects. Exposure to high concentrations of ammonia can cause irritation of the eyes, nose, throat, and lungs, and can lead to coughing, shortness of breath, and burns. In severe cases, exposure to ammonia can be fatal.
2. Ammonia is a highly reactive chemical, and leaks can lead to fires and explosions. This can cause significant damage to property and infrastructure and can put people's lives at risk.
3. Ammonia is also harmful to the environment. Ammonia leaks can contaminate air, water, and soil, and can harm plants and animals.
4. Ammonia is widely used in industry, agriculture and some households, therefore leaks can happen in many different settings and locations.
5. Ammonia leaks can have economic impacts as well. Businesses and communities can suffer significant economic losses due to damage to property and infrastructure, as well as lost productivity and revenue.

Furthermore, given the potential for serious harm, it is important to have proper safety measures in place to prevent and respond to ammonia leaks. This includes regulations, guidelines and standard practices, emergency response plans, training programs, and regular inspections and maintenance of equipment and facilities that handle ammonia. There have been several historical events where ammonia releases have caused significant harm to human health and the environment. Some examples include (NDTV,2023)

1. In 1948, a train carrying liquid ammonia derailed in Cleveland, Ohio, causing a massive explosion that killed 130 people and injured many more.
2. In 1992, an ammonia leak at a cold storage warehouse in East Oakland, California, killed one person and injured over 100 others.
3. In 2004, a chemical plant in Toulouse, France, leaked over 30 tons of ammonia, killing one person and injuring over 2,000 others.
4. In 2007, a massive ammonia leak from a refrigeration unit at a meatpacking plant in Missouri killed six workers and injured dozens more.

5. In 2008, an ammonia leak at a chemical plant in China killed 18 people and injured over 300 others.
6. In 2017, an ammonia leak at a cold storage facility in China killed 15 people and injured over 30 others.

These are just a few examples of the many historical events where ammonia releases have caused significant harm. Ammonia is a toxic chemical that can cause severe respiratory problems and other health effects, and it is important to have proper safety measures in place to prevent and respond to ammonia releases.

Wind Rose

A wind rose is a graphical representation of the distribution of wind speeds and directions at a specific location. It is often used to understand the dominant wind patterns and how they may influence the dispersion of pollutants such as ammonia. In the Climatic reference book of Bulgaria (1982), the conventional wind roses are depicted with 8 compass directions, one for each 45o of the horizon. On the outside circle is a representation of the wind's direction, and on the inner circles is a representation of its speed (Science & Information Climate-Smart Nation, 2023). When it comes to ammonia dispersion, the wind rose can be used to understand how the dominant wind patterns in a specific location may influence the spread of ammonia emissions. For instant, if the wind rose reveals that the predominant winds are blowing from an ammonia source, like a fertiliser plant, towards a sensitive receptor, like a residential area, it may be a sign that the ammonia emissions from the source pose a greater risk to the local residents. Additionally, the wind rose can be used to understand how the distribution of ammonia emissions in the atmosphere may be influenced by the wind patterns (Dore et al., 2006; Kim et al., 2020). How the ammonia emissions will be carried and dispersed in the atmosphere can be determined by the predominant winds, as indicated by the wind rose. In conclusion, the wind rose is a crucial tool for comprehending the local wind patterns and how they could affect the dispersion of ammonia emissions. It can be used to evaluate any dangers connected to ammonia emissions and offer suggestions for reducing or preventing those risks.

Typical wind rose in Bintulu

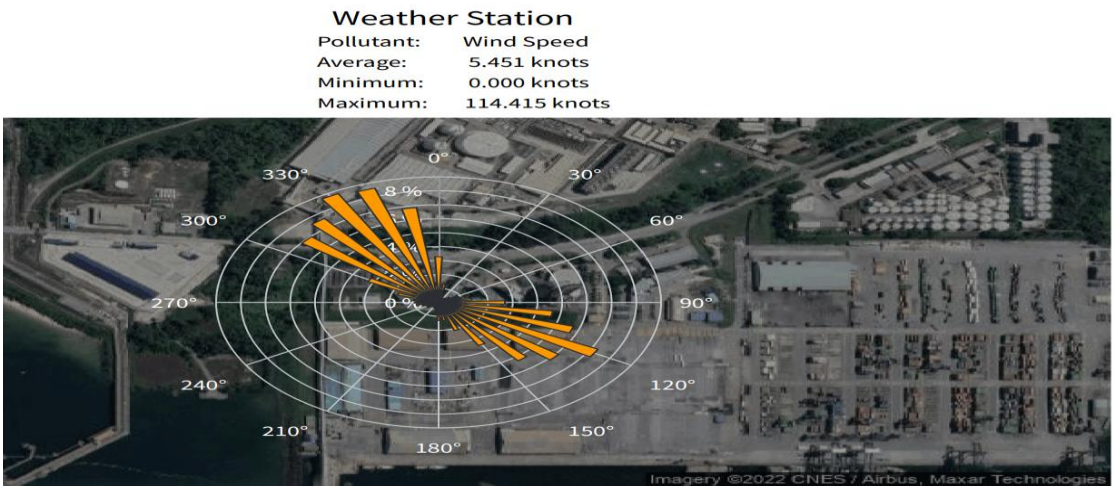

Figure 1 Wind Rose in Bintulu
Source: Envirosuite Software

Prediction of Ammonia Migration

Based on current climatic circumstances, topographical profiles, and physical characteristics of released chemicals, there are numerous mathematical models that accurately depict the dispersion of a chemical plume (Renard et al., 2004). Prediction of ammonia migration involves using mathematical models and simulations to predict the transport and dispersion of ammonia in the atmosphere. There are several factors that are taken into account when predicting ammonia migration, including

1. Meteorological data: This includes information on wind speed and direction, temperature, humidity, and other weather conditions that can affect the transport and dispersion of ammonia.
2. Topographical data: This includes information on the terrain and land cover, as well as the location and height of buildings and other structures, which can affect the transport and dispersion of ammonia.
3. Emission data: This includes information on the source of the ammonia release, such as the location and strength of the release, as well as the type and amount of ammonia that is being released.

There are different models and simulations that can be used to predict ammonia migration (Anfossi & Physick, 2005; Holmes & Morawska, 2006; Lotrecchiano et al., 2020), including

1. Gaussian plume models: These models use mathematical equations to simulate the transport and dispersion of ammonia based on the meteorological data, topographical data, and emission data. They are widely used to predict the dispersion of pollutants in the atmosphere.
2. Lagrangian particle models: These models simulate the transport of individual particles of ammonia in the atmosphere and are useful for predicting the dispersion of ammonia in complex terrain.
3. Eulerian models: These models are based on the numerical solution of the governing equations of fluid dynamics and are useful for simulating the transport and dispersion of ammonia over large spatial and temporal scales.

By using mathematical models and simulations, it is possible to predict the transport and dispersion of ammonia in the atmosphere and to estimate the potential risks associated with ammonia releases. These forecasts can help guide choices for limiting or reducing the dangers of ammonia leaks (Shirali, 2018).

Utilizing Wind Rose for modelling of ammonia release with Aloha Software

This paper researchers are using the prominent wind speed and direction using the information from wind rose and predicting the migration using Aloha Software. In addition, its depending on the season and location, wind patterns might change significantly. Sea breezes frequently influence wind direction in coastal regions like Bintulu, while storms and pressure systems can have an impact on wind speed (Alizadeh et al., 2014; Abbaslou, 2019). The movement and effects of ammonia in a particular area can be predicted using a wind rise and the Aloha software (see table 2 and table 3), the computational model for forecasting chemical emissions. The Aloha software can be used to calculate the dispersion of chemicals, such as ammonia, in the atmosphere based on the wind data, while the wind rose can provide information on the predominant wind patterns and the directions at a certain place. Also, the aloha software can model the movement and dispersion of ammonia in the atmosphere and forecast where it may migrate to by feeding it the wind data from the wind rose. Additionally, Aloha can be used to predict the potential health impacts of an ammonia release by estimating the concentration of the chemical at different locations and the length of time that people may be exposed to it (Shirali, 2018).

Predicted Prominent Migration

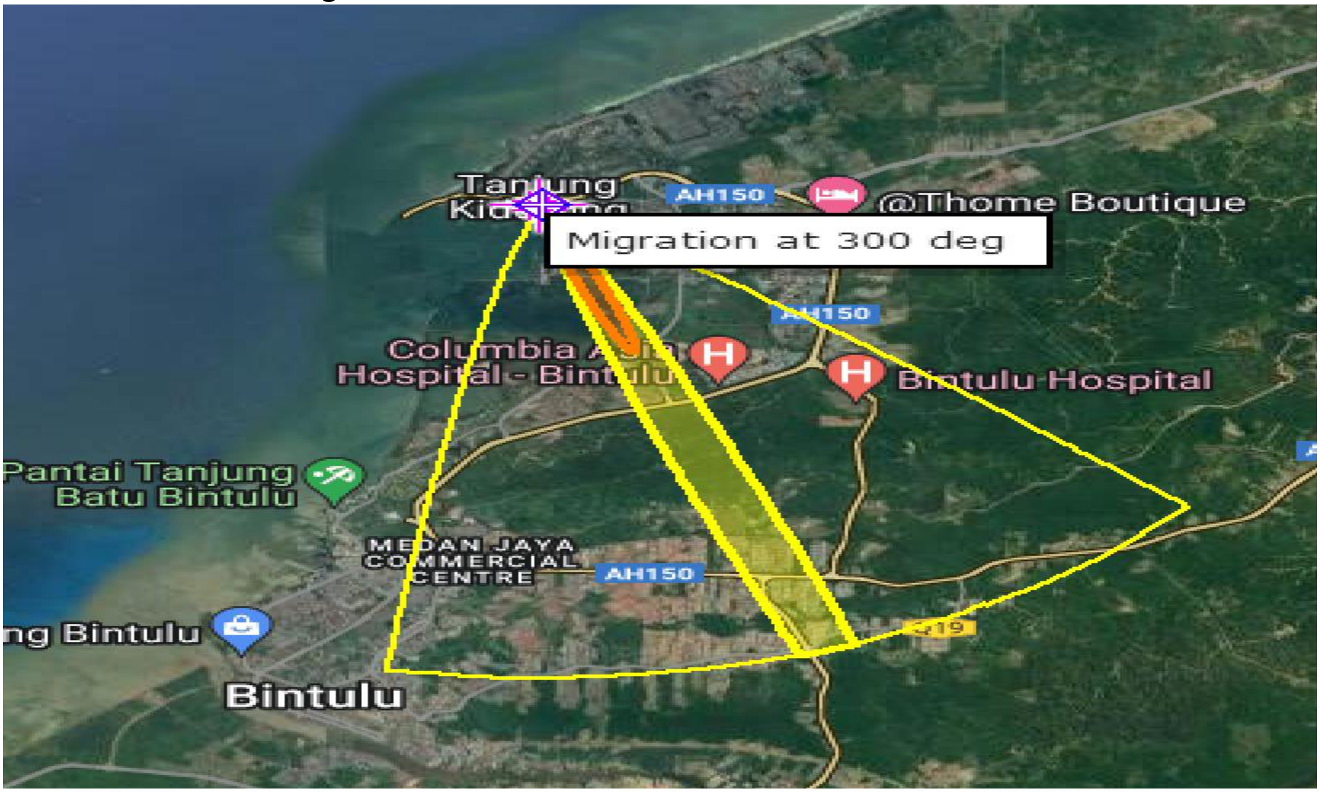

Figure 2 The Wind Rose 5 knots, direction 300 degrees
Source: Aloha Open Software

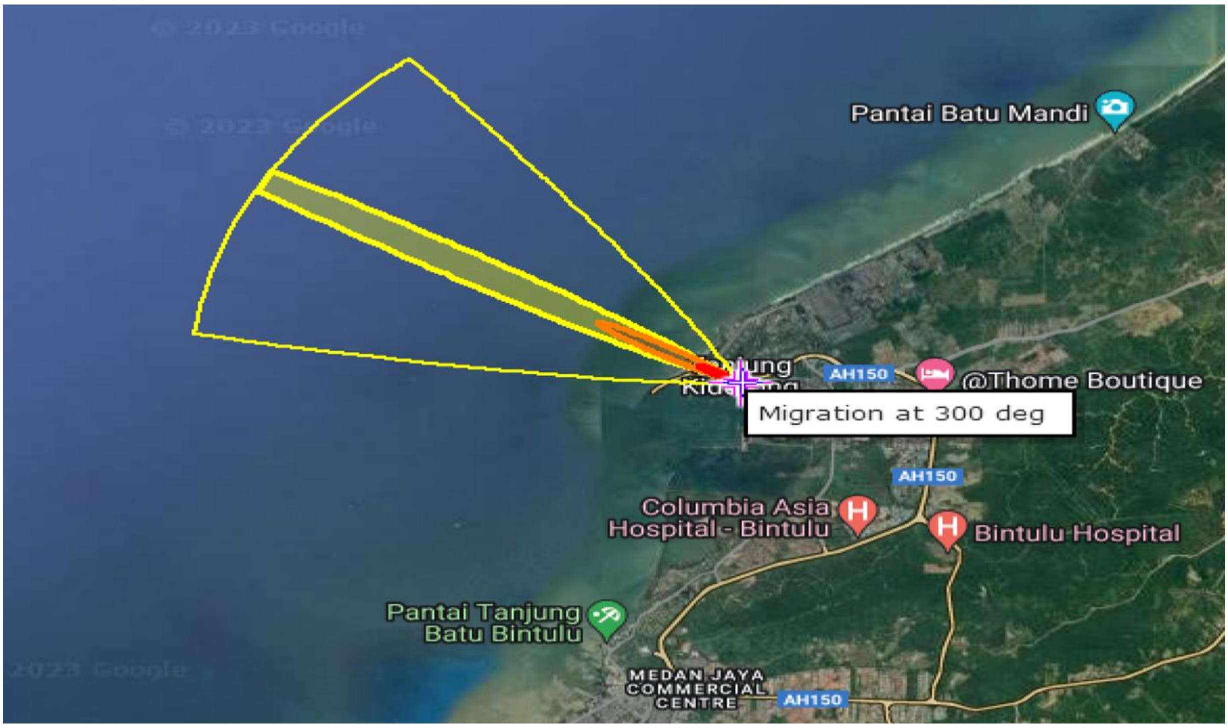

Figure 3 The Wind Rose 5 knots at 120 degrees
Source: Aloha Open Software

Conclusion

In summary, by combining the information from a wind rose and the Aloha software, it is possible to predict the migration and impact of ammonia releases in a specific location. This can be used to assess the potential risks associated with ammonia releases and to make recommendations for controlling or mitigating those risks. With the above information, mitigation measures can be undertaken by the emergency response personnel.

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