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Original Research

Ammonia Dispersion from Landfills (Case Study: Ganet Landfill, Tanjung Pinang)

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Abstract
Background: Landfills are recognized sources of emissions of various gaseous pollutants, including ammonia (NH_3), which can cause odor nuisances. The Ganet Landfill in Tanjungpinang City is currently managed using an open dumping system due to operational limitations.
Objective: This study aimed to analyze the dispersion profile of ammonia gas originating from the Ganet Landfill and to examine the differences in its dispersion patterns between the rainy and dry seasons.
Methods: Ammonia concentration data were collected based on one-hour average measurements at ten monitoring locations: one at the landfill unloading area and nine at surrounding points, including residential zones and adjacent roadways. These data were utilized as input for dispersion modeling using AERMOD software. Meteorological data for the year 2023 were estimated using historical data from 2019 to 2023 to support the modeling process.
Results: The monitoring results indicated that ammonia concentrations at all measured locations complied with the quality standard of <2 ppm. AERMOD modeling for one-hour average concentrations showed that the highest predicted concentration within the landfill area was 0.08 μg/Nm^3. In both the rainy and dry seasons, the dispersion of ammonia was predominantly toward the southwest, aligning with the prevailing wind direction in the area. The seasonal comparison revealed a difference in ammonia concentrations at a 7 km radius from the landfill center: 0.001 μg/Nm^3 during the rainy season and 0.002 μg/Nm^3 during the dry season.
Conclusion: The modeling results corroborated the monitoring findings, indicating that the highest concentrations of ammonia occur at locations closest to the landfill, particularly in the southwest direction, consistent with the dominant wind patterns.

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Background

Nowadays, air pollution is a serious problem in big cities, since municipal solid wastes contain high amounts of organic compounds. Solid waste management (SWM) is one of the key responsibilities of city administrators and one of the effective proxies for good governance. Globally, MSW generation is expected to increase to 3.40 billion tonnes by 2050 (Kaza, Yao, Bhada-Tata, & Van Woerden, 2018). In general, waste management practices tend to improve going from low-income to high-income countries (Abubakar et al., 2022; Vinti et al., 2021). But in another side Waste management in developing countries faces complex challenges. Rapid population growth and urbanization are causing an increase in the amount of waste generated. On average, each person produces about 0.74 kilograms of waste per day, and this figure can be even higher in high-income countries. This places an additional burden on already weak waste management systems. (Julia Lingga, Yuana, Aulia Sari, Nur Syahida, & Sitorus, 2024)

Many areas in developing countries lack adequate waste management facilities, such as standard landfills and recycling facilities. This lack of infrastructure makes it difficult to collect, sort and process waste effectively, resulting in much of it ending up in places it shouldn't be, such as rivers and the surrounding environment. (Achmad, 2024). Currently, there are still landfills that use an open dumping processing system, in which waste is simply dumped in a large and open area. Open dumping and landfilling are the most widely used practices for municipal solid waste (MSW) management due to low costs and less treatment efforts (Al-Wabel et al., 2022).

This method is not recommended because of the potential environmental pollution, according to Indonesia Government Regulation No. 18 of 2008 concerning waste management (Hamidi, 2023). MSW comprises of metals/metalloids, organic compounds, micropollutants, inorganic macro-components, xenobiotic compounds, and dioxins. The vertical and lateral transmission of toxin-laden leachates, emission of greenhouse gases (GHG), and generation of odor and dust from open dumping and landfilling result in the contamination of water and soil resources globally. The concentration of potentially hazardous pollutants in soil, air and water resources after releasing from MSW landfills and open dumps is presented (Al-Wabel et al., 2022).

The foul odor arises from the decomposition of waste by aerobic and anaerobic microorganism activities, producing hydrogen sulfide gas (H2S), methane gas (CH4), ammonia gas (NH3), sulfur dioxide (SO2), and nitrogen dioxide (NO2), causing a foul odor in the landfill. These odor-causing gases are harmful and toxic to the body of living organisms (Al-Wabel et al., 2022). The impact of odorous gases emitted from refuse transfer stations has always been a concern raised by the surrounding residents (Chai et al., 2022).

One of the odor-causing gases emitted from landfills is ammonia, which is landfill gas that can be formed by the decomposition of waste by volatilizing bacteria and chemical reactions. The decomposition of waste by bacteria is the most dominant process because landfill waste consists of organic compound components. It is important to know the distribution of ammonia as one of the gases that cause odor impacts. Ammonia dispersion modeling is one of the approaches used to identify the extent of the odor impact. There are various methods to estimate the emission of methane, including site evaluation, field testing, and mathematical modeling (Knapp, Laur, Vadas, Weiss, & Tricarico, 2014). The simplest model that can be used to simulate the ammonia dispersion is the Gaussian model. This model is considered the most traditional and inexpensive model to use. The Gaussian model is suitable for implementation under modeling conditions with low wind speeds and complex land topography. One application that can be used to simulate dispersion models with the Gaussian model is AERMOD (American Meteorological Society and Environmental Protection Agency Regulatory Model).

AERMOD is used for understanding the dispersion of pollutants over the chosen area, and requires hourly surface and upper air meteorological observations (Allen et al., 2013). This software can simulate the dispersion of atmospheric pollutants from point and aerial source emissions (Asadi, Asadollahfardi, Fakhraee, & Mirmohammadi, 2017; Esbrí, López-Berdonces, Fernández-Calderón, Higueras, & Díez, 2015). Dispersion modeling research has been widely conducted, even in Indonesia. In addition, in a previous study conducted by Jawwad, Murti, & Citrasari (2023), ambient air quality data collection at the landfill was only carried out on one day in June 2022, namely, during the dry season. Although numerous studies have been conducted on the production and emission of pollutants from landfills but, no study has been conducted on the disposal area of Ganet, Kepulauan Riau, Indonesia.

Ganet is one of region in Tanjungpinang City that still landfills that use an open dumping processing system. It was located around 2 Kilometers from the residential. Previous studies that held in dry season has detected the concentration of NH3 in ambient air which was measured at the Ganet landfill at 4 sampling points, it was found that the four points did not exceed the threshold. However, the highest ammonia parameters were in the flaring zone with a concentration of 0.11 ppm and the lowest in the scavenger settlement zone with a concentration of 0.07 ppm Exposure to ammonia gas can cause upper respiratory tract infections and other disease in human body (Simbolon, Daswito, & Samosir, 2023).

New and old waste piles can be in different stages of decomposition (Marković & Stevović, 2016). Yi et al. (2021) reported differences in ammonia concentrations at various points in landfills (Yi, Zhang, & Smith, 2021). The difference depends on the characteristics of each area tested, including the landfill, leachate management, sludge management, and fly ash management areas. The sludge management and sludge dewatering areas had the highest ammonia concentrations. In addition, it was also found that the difference in ammonia concentration in each season significantly depends on the ambient air temperature, which is shown by an increase in ammonia concentration in summer compared to that in winter.

Despite the known risks associated with ammonia emissions, including air pollution, odor nuisance, and potential health hazards such as respiratory irritation, there has been limited research on its dispersion patterns from landfills, especially in different seasonal conditions. This study aims to address this gap by analyzing ammonia emissions alongside other pollutants at the Ganet Landfill. However, no prior research has specifically examined emissions and their distribution patterns in this context.

Unlike previous studies that primarily focused on air quality monitoring during the dry season, this research includes ambient air quality assessments during the rainy season. By incorporating both seasonal variations, it provides a more comprehensive and representative understanding of ammonia dispersion and overall landfill emission distribution patterns throughout the year. The findings of this study will offer valuable insights for landfill managers, aiding in the development of effective mitigation strategies to minimize ammonia exposure risks for workers and nearby communities. Additionally, it will contribute to broader environmental policies aimed at improving waste management and air quality control in landfill areas.

Methods

Design

This study employs a dispersion modeling approach to assess ammonia (NH_3) emissions from the Ganet Landfill in Tanjung Pinang, Indonesia. The American Meteorological Society and Environmental Protection Agency Regulatory Model (AERMOD) was selected due to its suitability in modeling air pollutant dispersion from area sources. AERMOD applies a Gaussian dispersion model, integrating meteorological, topographical, and emission data to simulate pollutant distribution accurately (Matacchiera et al., (2019) AERMOD is particularly effective in modeling ammonia emissions as it integrates meteorological data, terrain information, and emission sources to simulate pollutant dispersion accurately.

Subject

The study focuses on ammonia dispersion from the landfill and its impact on surrounding residential areas. The primary emission source is the landfill's unloading zone, where fresh waste is deposited. Ammonia concentration measurements were conducted at ten locations: The landfill unloading area, Alam Tirta Lestari Housing, Bukit Permata Putih Housing, Kenangan Semoga Jaya 2 Housing, Grace Permata Indah Housing, Satria 11 Housing, Pucuk Merah Housing, Satria Road andAirport Road. Sampling was carried out for 1 hour for each point. Measurements were made once at each point from May 6 to 8, 2024. Measurements used an impinger with the indophenol method.

Variables

Variables in this study are Meteorological conditions (wind direction, wind speed, temperature, solar radiation), topographical characteristics and Ambient ammonia concentration levels at different locations which is north and south. With the control variables are Sampling duration, equipment calibration, and measurement protocol consistency. AERMOD was used to simulate ammonia dispersion under three scenarios:

1. Annual dispersion model – Evaluates ammonia distribution over the year.
2. Dry season model – Assesses ammonia dispersion under higher temperatures and lower humidity.
3. Rainy season model – Examines ammonia transport under increased precipitation.

Ammonia concentrations were compared to the Indonesian air quality standard (Minister of Environment Regulation No. 50 of 1996). Statistical analyses, including correlation tests and dispersion pattern evaluations, were conducted using SPSS.

Instrument

Ambient ammonia concentrations were measured using an impinger, which captures gaseous pollutants in a liquid medium for laboratory analysis. A UV-Vis spectrophotometer was used to quantify ammonia levels. The emission rate was calculated following the Indonesian Minister of Environment Regulation No. 50 of 1996 and SNI 19-7119.1-2005 standards.

Meteorological data, including wind speed, wind direction, temperature, and solar radiation, were obtained from the Meteorology, Climatology, and Geophysics Agency. Five years of historical meteorological data (2019–2024) were analyzed to observe variability, while 2024 data represented current conditions.Topographical data from the United States Geological Survey (USGS) were integrated into AERMOD using a digital elevation model (DEM) to assess the impact of land height on ammonia dispersion.

Data collection

Sampling was conducted at 10 points, namely 1 unloading point and 9 residential points around the landfill. Data on the sources of ammonia gas pollutants in the air were obtained from previous studies. Ammonia gas concentrations in the ambient air were measured at the landfill sit and in the neighborhood around the landfill (Figure 1). The unloading point is the location at the Ganet landfill where waste is unloaded by the garbage truck. This unloading point is also the location where scavengers sort out waste that still has a selling value.

Meteorological data (wind speed, sunlight intensity, temperature fluctuations, and other meteorological data) throughout the year obtained from the Tanjungpinang City Meteorology, Climatology and Geophysics Agency in the dry season and rainy season and contour data obtained from the United States Geological Survey (USGS).

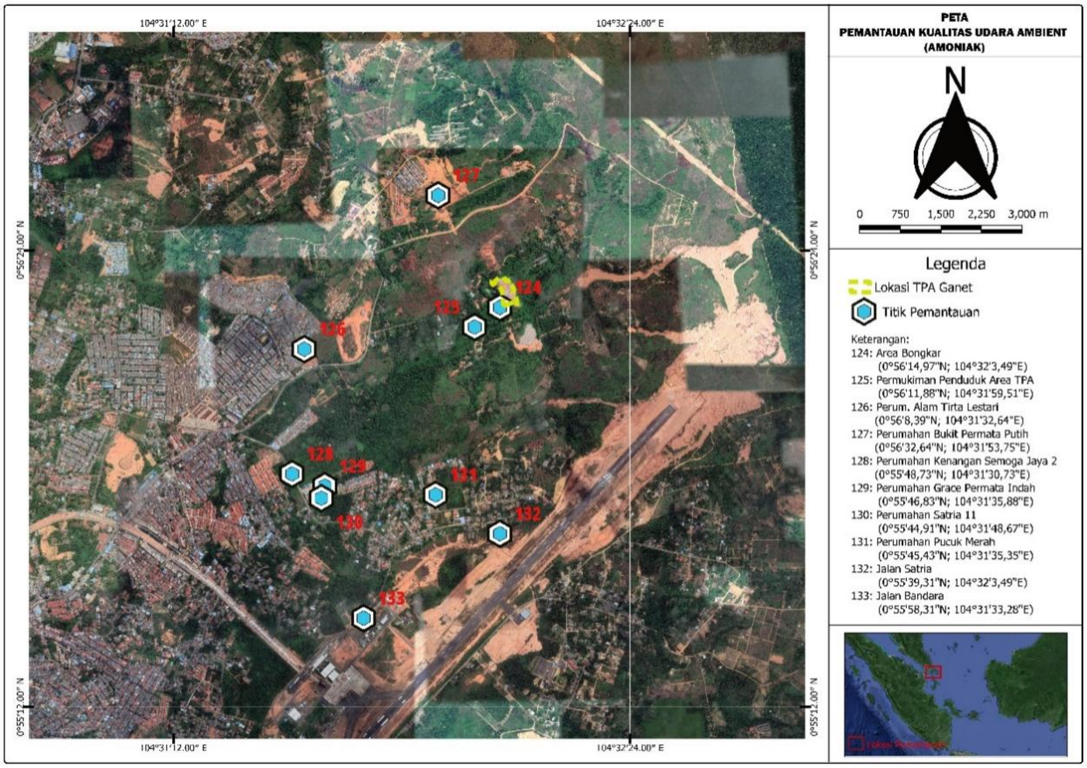


Figure 1. Ammonia concentration monitoring points

Data analysis

The results obtained from air quality measurements of ammonia concentrations at the unloading point were then modeled using the AERMOD software, which uses the principle of the Gaussian dispersion model. The AERMOD model uses emission rate data from area pollutant sources, which in this study was calculated based on ammonia concentrations in ambient air at the point of landfill unloading.

To perform dispersion modeling, meteorological data are required, including wind direction and speed, sunlight intensity, temperature fluctuations, and other meteorological data for one year obtained from the Meteorology, Climatology, and Geophysics Agency. Meteorological data for five years (20192024) were used to complement meteorological data for one year. Contour data around the Ganet Landfill in Tanjung Pinang City was obtained from the United States Geological Survey (USGS) in order to obtain the influence of terrain contours on the ammonia contamination dispersion model.

Dispersion modeling with AERMOD was performed by first processing the meteorological data in the AERMET. Using the emission load data from the landfill, processed meteorological data, and contour data, a simulation of ammonia gas dispersion from the Ganet landfill area source can be carried out. Modeling was conducted using meteorological data throughout the year, in the dry season, and in the rainy season. The values of the measurement results and the results of the dispersion simulation were then compared with the NH3 quality standard in the Decree of the Minister of Environment Number 50 of 1996.

Ethical Considerations

This study complied with ethical research standards, with approval obtained from Komite Etik Penelitian Kesehatan Poltekkes Kemenkes Tanjungpinang Kepulauan Riau, Approval Number PL.01.03/F.LIV.17/006/2024.Residents in sampled areas were informed about the study, and no personal data were collected.

Results

Identify sources of air pollution

The Ganet Landfill is located in Tanjungpinang City. TPA Ganet is managed by UPTD Ganet under the auspices of the Tanjungpinang City Government. The service area of TPA Ganet includes the Tanjungpinang Kota Sub-district, Tanjungpinang Barat Sub-district, Tanjungpinang Timur Sub-district, and Bukti Bestari Sub-district, with the average weight of waste transported every day reaching 92 tons.

The number of landfill zones in the Ganet Landfill, which is five, is different from the initial design of the Ganet Landfill Management, which divided the four landfill zones. In the initial planning, the Ganet Landfill was designed to be managed in two different systems, Zone 1 (1 ha), Zone 2 (0.9 ha), and Zone 3 (1.3 ha), managed under a controlled landfill system, and Zone 4 (1.5 ha), managed under a sanitary landfill system. Only zone 3 is still active, while zones 1 and 2 are no longer active, and zone 3 is already closed. Zone 5 (3.8 ha) is still in the planning stage. In addition to the backfill zone, the Ganet landfill has a weighbridge, septage treatment, and composting facilities (Rahmawati, Kurnianingsih, & Okparizan, 2023) .

Based on the manager's statement, the Ganet Landfill is managed using the sanitary landfill method in accordance with Law No. 18/2008, which is waste management by burying waste in a pit, which is then covered with soil cover routinely every day after the backfilling activity ends, and the pile is then compacted. Rahmawati et al. (2023) Explained that from the time the Ganet landfill began to be operated, namely in 2014 until 2017, the Ganet landfill was managed by sanitary landfill, but due to the waste load that needed to be stockpiled and inadequate operational equipment, causing the Ganet landfill to no longer be managed by sanitary landfill (Rahmawati et al., 2023). This result is in accordance with the observations of Simbolon, Nurmaini, & Hasan, (2019), who stated that the Ganet landfill is not managed by sanitary landfill because there is no closure of the waste pile with soil cover every day after the end of landfilling activities; therefore, the more appropriate waste management at the Ganet landfill is open dumping(7).

Figure 2. Pollutant source (Unloading Area)

Air quality measurement results

The concentrations of ammonia in the ambient air at the landfill and at several points around the landfill are shown in Table 1. Based on the Decree of the Minister of Environment number 50, 1996, for the standard level of odor, the standard level of ammonia concentration was 2 ppm. Therefore, from the results of the ambient air quality measurements carried out in this study, there were no monitoring points in the landfill or the surrounding environment that had ammonia concentrations in ambient air that exceeded the reference standard level of odor.

The unloading area at the landfill is the monitoring point with the highest ammonia concentration, when compared to the ammonia concentrations at other monitoring points. This is in line with other studies where the highest landfill gas concentrations were found in the landfill area (Jawwad et al., 2023; Simbolon et al., 2019) . Bukit Permata Putih Housing (Bukit Merpati Putih Housing) located ± 621 m to the north of the Ganet Landfill Unloading Area, is a housing estate with the highest ammonia concentration compared to other monitoring points in the neighborhood around the landfill, with an ammonia concentration of 0.14 ppm. Bukit Merpati Putih Housing, followed by Grace Permata Indah Housing and Alam Tirta Lestari Housing, which are located ±1.22 km away from the Landfill Unloading Area in the Southwest, and ±971 m in the West, respectively. Compared to ammonia concentrations in the Residential Housing of the Landfill Area, ammonia concentrations in ambient air are higher at monitoring points in Bukit Merpati Putih Housing, Grace Permata Indah Housing, and Alam Tirta Lestari Housing. This is because the Landfill Area Residential Housing is located closer to the Landfill Unloading Area than the three housing estates, which is 157 m to the west.

The location of other monitoring points to the unloading area at the Ganet Landfill, namely Pucuk Merah Housing is ±967 m in the Southwest direction with an ammonia concentration of 0.09 ppm, Jalan Bandara ±1.07 km in the West direction with an ammonia concentration of 0.08 ppm, Satria Road ±1.1 km in the South direction with an ammonia concentration of 0.07 ppm, Satria 11 Housing ±1.04 km in the Southwest direction with an ammonia concentration of 0.04 ppm, Kenangan Semoga Jaya 2 Housing is located ±1.3 km in the Southwest direction with an ammonia concentration of 0.02 ppm.

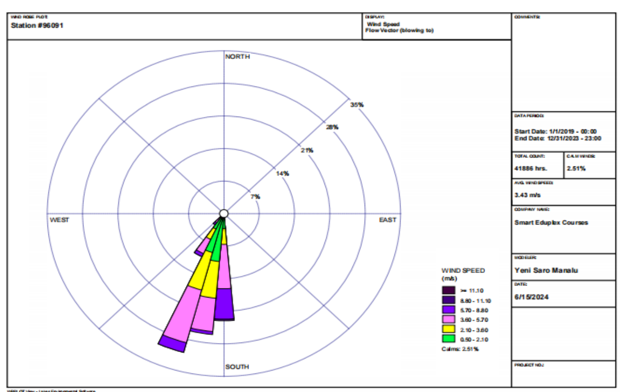
Table 1. Results of measuring ammonia concentration at Ganet landfill and the surrounding environment

Sample code number	Location	Coordinate		Result (ppm)
		Northing	Easting	
0124	Unloading Area	0°56'14,9748	104°32'03,4908	0,16
0125	Population Settlement Landfill Area	0°56'11,8788	104°31'59,5092	0,09
0126	Alam Tirta Lestari residende	0°56'08,394	104°31'32,6352	0,11
0127	Bukit Permata Putih Housing	0°56'32,64	104°31'53,7492	0,14
0128	Kenangan Semoga Jaya 2 residence	0°55'48,7272	104°31'30,7272	0,02
0129	Grace Permata Indah residence	0°55'46,8228	104°31'35,8788	0,12
0130	Satria 11 residence	0°55'44,9112	104°31'48,6732	0,04
0131	Pucuk Merah residence	0°55'45,426	104°31'53,3532	0,09
0132	Satria Street	0°55'39,3132	104°32'03,4908	0,07
0133	Bandara Area	0°55'58,314	104°31'33,2832	0,08

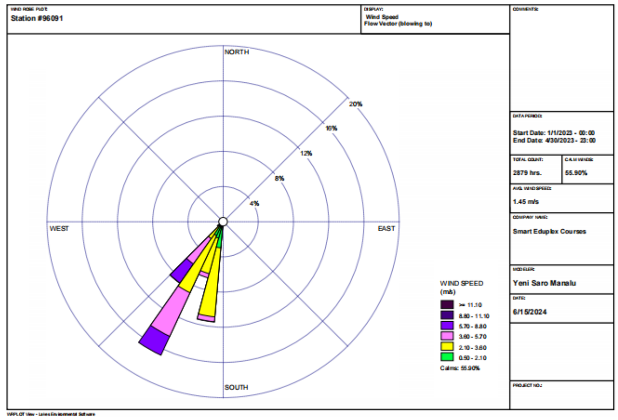
Air quality dispersion model

Ammonia dispersion modeling from the landfill uses emission rate inputs based on ammonia concentrations in ambient air from monitoring results in the Unloading Area so that the input emission rate data is 0.16 g.s-1. m-2 in the dispersion model during the dry season. As for the dispersion model in the rainy season, emission rates are assumed to have a lower level, which is 29.9% lower than the concentration in the dry season; therefore, for ammonia dispersion modeling at the Ganet Landfill, the value is 0.124 g.s-1. m-2.

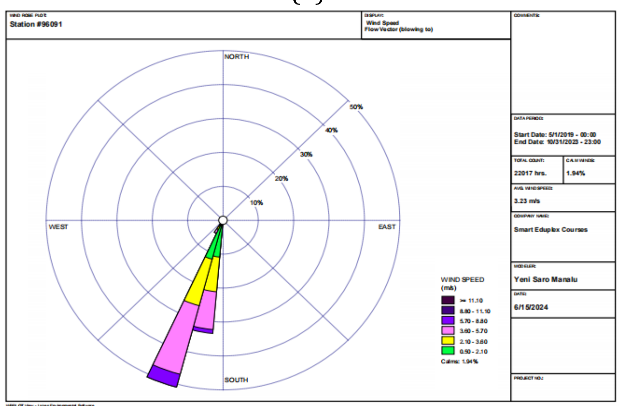
Meteorological data for five years (2019-2023) were used to complete the last year of meteorological data (2023). The results of the wind rose modeling for the Ganet landfill area in 2023 are shown in Figure 3. From the WR Plot model, it was found that the wind direction in the rainy and dry seasons blows to the southwest, similar to the average wind direction for one year.



(a)



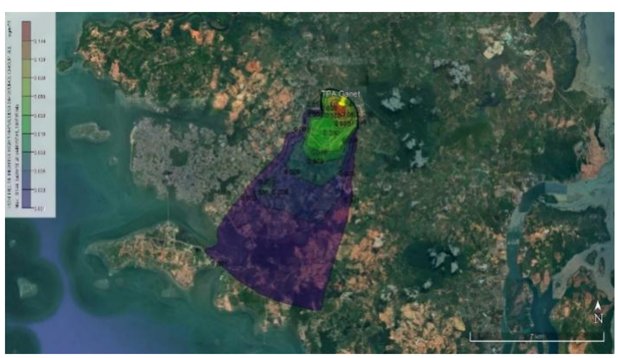
(b)



(c)

Figure 3. Wind rose (a) for one year, (b) wet season, and (c) dry season

Using emission rate data and meteorological data, the ammonia dispersion model for one-hour average concentrations in the wet and dry seasons is shown in Figure 4. Based on the ammonia dispersion model for one-hour average concentrations, it can be seen that ammonia dispersion is centered on the Ganet landfill area owing to the influence of topography, dominant wind direction, and land cover around the landfill adjacent to residential buildings. The Ganet landfill area received ammonia concentrations for a 1-hour average of 0.144 - 0.08 μg/m3, which indicates that at the perimeter of the landfill, ammonia concentrations in the rainy season and dry season are the same, at 0.08 μg/m3. Ammonia was dispersed to the southwest, where at a radius of 7 km from the source center, the 1-hour average concentration of ammonia based on the modeling results was found to be 0.001 μg/m3 during the rainy season and 0.002 μg/m3 during the dry season. The difference in ammonia concentration was due to the different emission rate input for the two seasons.



(a)

(b)

Figure 4. Ammonia gas dispersion model for 1-hour average concentration in (a) wet season, and (b) dry season

From the dispersion model, it can be seen that the distribution of ammonia concentration is in line with the wind direction, which is more dominant in the southwest. This is similar to the measurement results of ammonia concentrations in ambient air, with high ammonia concentrations in the neighborhood around the Ganet Landfill, located in the Grace Permata Indah Housing and Perum. Alam Tirta Lestari. Although Bukit Merpati Putih Housing is located to the north of the Ganet Landfill, this point has the highest concentration of ammonia in ambient air compared to other measurement points around the landfill environment. This is because it is closer to the landfill than to the other monitoring points. This is as seen in the dispersion modeling results, where within a certain radius, the ammonia concentrations are spread evenly in all directions.

Discussion

Ammonia is generated through the decomposition of organic matter by microorganisms in waste backfill zones (Adeniyi, Bello, Mukaila, Sarker, & Hammed, 2023), especially in open dumping landfills. This system exacerbates the release of ammonia gas because the waste is left exposed without soil cover, allowing the gas to evaporate easily into the atmosphere. Consequently ammonia accumulates around landfills, which has a negative impact on the environment and public health(Abubakar et al., 2022).

The findings of this study highlight the impact of the open dumping system on ammonia emissions and its potential health risks for nearby communities. Previous studies have demonstrated that inadequate landfill management contributes to increased ammonia concentrations in the air (Rahmawati et al., 2023). The results of this study confirm these findings, emphasizing the need for improved waste management strategies to mitigate air pollution and its associated health effects. This method does not involve the daily covering of waste with soil; thus, ammonia gas produced from waste decomposition is easily released into the air. The open dumping system Ganet landfill exacerbates ammonia gas emissions owing to the absence of an effective mechanism to reduce gas volatilization from the waste pile(Ferronato & Torretta, 2019). Based on the findings of Yi et al., (2021) increased ammonia concentrations occur in poorly managed landfill areas, such as zones that are not covered by soil. This was also corroborated by Lim, Cha, Kong, & Baek (2018), who showed that sludge management areas and irregular backfill areas are often the main sources of ammonia emissions.

The concentration of ammonia in residential areas surrounding the Ganet Landfill was found to be significantly higher than recommended air quality standards. Continuous exposure to ammonia at low concentrations can lead to respiratory irritation and other health complications, particularly in vulnerable populations such as children and the elderly (Alsarami et al., 2024). According to health standards, exposure to ammonia levels exceeding 25 ppm for prolonged periods can cause severe respiratory distress (WHO, 2021). These findings suggest an urgent need for stricter monitoring and regulatory enforcement in waste disposal practices.

In addition to direct health impacts, ammonia emissions contribute to broader environmental degradation. The AERMOD model and WR Plot modeling used in this study provide valuable insights into the dispersion patterns of ammonia gas, illustrating how meteorological conditions influence pollutant distribution. Based on the results of this study, the loading and unloading areas at the Ganet landfill were identified as the points with the highest ammonia concentrations. This finding is supported by the results of Jawwad et al., (2023); Simbolon, Nurmaini, & Hasan, (2019), who showed that unloading areas in landfills are often a significant source of ammonia gas emissions. The high volume of freshly unloaded waste and lack of soil cover contribute to the release of large amounts of ammonia gas (Zhao, Zheng, Wang, & Fan, 2024).

AERMOD is a widely used air dispersion model that estimates pollutant concentrations based on emission sources, meteorological data, and terrain characteristics. Similarly, WR Plot modeling visualizes wind patterns and their role in the spread of airborne contaminants. The integration of these models strengthens the study's findings by offering a comprehensive analysis of ammonia diffusion and its potential risks. (Pohl et al., 2022; Wyer, Kelleghan, Blanes-Vidal, Schauberger, & Curran, 2022).

Despite these important findings, several limitations must be acknowledged. The study primarily focuses on ammonia emissions without considering the synergistic effects of other landfill gases such as methane and hydrogen sulfide. Future research should adopt a more holistic approach by assessing multiple pollutants and their combined impact on air quality and public health. Moreover, while this study provides a quantitative assessment of ammonia exposure, qualitative data on community health conditions would further enrich the analysis and policy recommendations.

Based on the results, several measures can be proposed to mitigate ammonia emissions and their associated health risks. Implementing controlled landfill techniques, such as sanitary landfilling and gas extraction systems, can significantly reduce ammonia release into the atmosphere (Ozbay, Jones, Gadde, Isah, & Attarwala, 2021; Siddiqua, Hahladakis, & Al-Attiya, 2022). Additionally, regular air quality monitoring in residential areas is essential to track pollutant levels and ensure compliance with safety standards(Petrou, Psistaki, Dokas, & Paschalidou, 2022). Public awareness campaigns and community engagement initiatives should also be strengthened to educate residents about the potential health risks and preventive measures(Anuardo, Espuny, Costa, & Oliveira, 2022; Hajam, Kumar, & Kumar, 2023)

Conclusion

The dispersion model of ammonia gas from the Ganet landfill source was conducted with input data based on the ammonia concentration monitored in the Unloading Area, which was 0.16 ppm for a 1-hour average concentration. Dispersion modeling in two different seasons, the rainy and dry seasons, showed an ammonia concentration at the perimeter of the Ganet Landfill of 0.08 μg/m3.Ammonia gas spreads in the dominant wind direction from the perimeter of the Ganet landfill, namely to the southwest, both in the rainy and dry seasons. The modeling results are in line with the monitoring results around the landfill area, where the highest ammonia concentration is in the northern part directly adjacent to the Ganet Landfill, namely in Bukit Merpati Putih Housing which is ± 621 m from the monitoring point of the Unloading Area at the landfill. The next highest concentration was found in Grace Permata Indah Housing and Perum. Alam Tirta Lestari, which is located ±1.22 km away from the Landfill Unloading Area in the Southwest, and ±971 m in the west. However, based on the modeling results, ammonia concentrations at a radius of ~7 km to the southwest of the landfill source center point for the rainy season and dry season have differences of, 0.001 μg/m3 and 0.002 μg/m3 for the rainy and dry seasons, respectively. Compared to the quality standard, both the modeling results and direct monitoring results show that the concentrations at all monitoring points are below the required quality standard for odor, which is <2 ppm. This study underscores the critical need for improved landfill management and air quality monitoring to minimize the adverse effects of ammonia emissions. The findings highlight the importance of integrating advanced modeling techniques in environmental assessments to enhance our understanding of pollution dynamics. Future research should explore long-term mitigation strategies, incorporating both technological advancements and policy interventions to ensure sustainable waste management and public health protection

Declaration of conflicting interest

The authors declare no potential conflict of interest.

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Author contributions

VAS was responsible for designing and drafting the study, analyzing and interpreting the results, and drafting the manuscript. LPY played a role in designing, analyzing, and interpreting the data. RD performed the analysis, data interpretation, and data collection. SMHM was involved in the analysis, interpretation of the results, and writing of the manuscript.

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