

Fly Density at Temporary Waste Storage Sites in West Ungaran, Semarang

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Abstract. Temporary Waste Storage Sites (TPS) are potential breeding and resting sites for flies because accumulated waste, particularly organic waste, can provide food and suitable environmental conditions. Fly density is an indicator of environmental sanitation, while temperature and humidity may influence fly activity and persistence. Objective: This study aimed to describe fly density characteristics according to temperature and humidity conditions at TPS in West Ungaran, Semarang Regency. Methods: A descriptive quantitative study with a cross-sectional approach was conducted at 28 TPS. The observed variables were fly density, air temperature, and air humidity. Data were analyzed descriptively using frequency distributions, percentages, minimum and maximum values, means, medians, and cross-tabulation of fly density categories with temperature and humidity categories. Results: Temperature ranged from 26.8–31.2°C, with a mean of 29.05°C and median of 28.6°C. Humidity ranged from 57–84%, with a mean of 70.54% and median of 67.5%. Fifteen TPS (53.6%) had low fly density and 13 (46.4%) had high density. Nineteen TPS (67.9%) were in the supportive temperature category and nine (32.1%) in the high category. For humidity, three TPS (10.7%) were categorized as low, 20 (71.4%) as supportive, and five (17.9%) as high. All TPS with high temperature had high fly density, while high fly density occurred in both supportive and high humidity categories. Conclusion: Low fly density was slightly more prevalent, but high density remained substantial. Temperature and humidity conditions at most TPS were supportive of fly presence.

Keywords: fly density, temperature, humidity, environmental sanitation

INTRODUCTION

Solid waste is an environmental problem that can affect public health when it is not properly managed. Accumulated waste can provide food sources and habitats for various organisms, including flies. The presence of flies in waste-management environments is a public health concern because flies may act as mechanical vectors of pathogenic microorganisms. Consequently, fly density can be used as an indicator of environmental sanitation (1).

Temporary Waste Storage Sites (TPS) are locations that can support fly presence. Accumulated waste, particularly decomposing organic waste, can provide both food and suitable conditions for fly development. Studies in TPS in Klaten, Wonogiri, Cirebon, and Bandung have indicated that waste-management conditions are associated with fly density. Inadequate sorting, collection, and transportation may increase waste accumulation and create conditions favorable for flies (2)(3)(4).

Poorly managed TPS can create environmental conditions that facilitate the persistence and proliferation of flies. Organic waste, food residues, and other biodegradable materials can serve as feeding substrates, while moisture and suitable temperature may support fly activity. When waste remains at the TPS for a prolonged period, the accumulation of organic material and moisture may increase the attractiveness of the site to flies. Therefore, environmental management at TPS is not only important for maintaining cleanliness but also represents an important component of preventive environmental health management.

Fly density is particularly important because a high fly population may indicate inadequate sanitation conditions and increase the potential for mechanical transmission of pathogenic microorganisms. Flies can move between waste, contaminated surfaces, food, and areas of human activity, potentially facilitating the mechanical transfer of microorganisms. Consequently, monitoring fly density at TPS can provide practical information for identifying locations that require improved sanitation and waste-management measures. Regular monitoring can also support the identification of environmental conditions that may contribute to increasing fly populations.

Physical environmental factors also contribute to fly presence. Temperature and humidity are microclimatic conditions that may influence fly activity and development. Studies in waste facilities have reported fly density in locations with temperatures around 28–29.5°C and humidity of 69–78% (<https://doi.org/10.17977/um062v3i62021p429-439>). Other research reported temperatures of 27.8–35.9°C and humidity of 48–70% at TPS in Samarinda, where all observed sites had high to very high fly density. These findings indicate that microclimate should be considered together with waste volume, accumulation duration, transportation frequency, and sanitation conditions.(6)

Temperature and humidity should therefore be considered as complementary environmental indicators in assessing fly density. Changes in these microclimatic conditions may influence fly activity, survival, and development.(3) However, favorable temperature and humidity conditions do not necessarily result in high fly density because other characteristics of TPS, such as the amount and type of waste, duration of waste accumulation, cleanliness of the surrounding area, drainage, and frequency of waste collection, may also influence the observed condition. Therefore, describing fly density together with temperature and humidity can provide a more comprehensive picture of the environmental conditions at TPS.

Previous studies have demonstrated that the influence of environmental factors on fly density may vary according to geographic location, characteristics of waste management, environmental conditions, and measurement procedures. Research on the relationship between temperature and humidity and fly density at Oeba Market, Kupang, highlighted the importance of environmental conditions in fly control. Another study in Batam found an association between humidity and the density of *Musca domestica*, whereas temperature was not significantly associated with fly density. These differences indicate that the contribution of individual microclimatic factors may vary according to local environmental characteristics, sanitation conditions, food sources, and measurement methods (7)(8).

Although previous studies have examined factors associated with fly density in waste-management areas, findings may vary according to the characteristics of each study location. This variation indicates the importance of obtaining location-specific information. In West Ungaran, information regarding fly density has previously been available, but the environmental characteristics accompanying the observed density, particularly temperature and humidity, require further description. Such information is useful for identifying the environmental conditions commonly found at TPS with different levels of fly density.

Environmental conditions are important characteristics to consider when assessing fly density in public environments. A recent study in traditional markets in Malang City, Indonesia, assessed fly

density using the fly grill method alongside measurements of temperature and humidity at several observation points. The study found variations in fly density across different market areas, with density ranging from low to high categories. These findings indicate that recording temperature and humidity alongside fly density can provide useful descriptive information for characterizing environmental conditions at fly-monitoring sites (9).

The present study addresses this recommendation by incorporating temperature and humidity as additional environmental characteristics accompanying fly density. These microclimatic parameters are important to consider because environmental temperature and relative humidity can influence fly activity, development, survival, and abundance, thereby contributing to temporal and spatial variations in fly populations. Previous studies conducted in different environmental settings have demonstrated that variations in temperature and humidity are accompanied by changes in fly abundance and activity, further supporting the importance of documenting these parameters when characterizing fly populations (13)(14)(15). Therefore, the inclusion of temperature and humidity in the present study provides a more comprehensive description of the microclimatic conditions in which fly density was observed. However, the study is descriptive in nature and is not intended to establish statistical associations or causal relationships. Instead, it provides a descriptive assessment of the distribution of fly density together with the prevailing microclimatic conditions at the study sites. This approach can provide baseline information for environmental sanitation monitoring and serve as a basis for subsequent analytical studies examining the relationships between microclimatic conditions, waste-management practices, and fly density.

Based on this context, the present study was conducted to provide a more specific description of fly density characteristics according to temperature and humidity at TPS in West Ungaran, Semarang Regency. The study uses measurements from 28 TPS to describe the microclimatic conditions accompanying fly density at the study sites. The findings are expected to provide useful information for routine environmental sanitation monitoring and support efforts to improve waste-management conditions at TPS.

METHODS

This study used a descriptive quantitative design with a cross-sectional approach. The objective was to describe fly density characteristics according to temperature and humidity conditions at TPS in West Ungaran, Semarang Regency.

The population consisted of TPS located in West Ungaran. The sample comprised 28 TPS, and data collection covered all TPS included as study objects. The same number of TPS had been examined in the previous study conducted in the same area.

The variables analyzed were fly density, air temperature, and air humidity. Fly density was categorized as low or high according to the categories in the study data. In the previous measurement at the same location, fly density was assessed using a fly grill, with high density defined as ≥ 2 flies and low density as < 2 flies during a 10×30 -second measurement. Temperature and humidity were analyzed using the categories contained in the study data.

Data were analyzed descriptively using frequency distributions and percentages. Minimum, maximum, mean, and median values were calculated for numerical variables. Cross-tabulation was then used to describe the distribution of fly density according to temperature and humidity categories. No association or causal-effect test was performed; therefore, the findings describe distributions and descriptive patterns only.

Ethical approval was obtained from the Research Ethics Committee of Universitas Ngudi Waluyo under ethical clearance number 53/KEP/EC/UNW/2026. The research process was conducted in accordance with applicable research ethics principles.

RESULT

Temperature characteristics

Measurements at 28 TPS showed that environmental temperature ranged from 26.8–31.2°C, with a mean of 29.05°C and a median of 28.6°C.

Table 1. Temperature characteristics at TPS in West Ungaran

Parameter	Result
Number of TPS	28
Minimum	26.8°C
Maximum	31.2°C
Mean	29.05°C
Median	28.6°C

The findings indicate that most TPS experienced relatively warm conditions. Temperature is one environmental factor that can influence insect activity. Windyaraini et al. (2025) reported temperatures of 28–29.5°C at TPST Piyungan in locations with high fly density. Fitrah and Thohira (2026) also reported a broad temperature range at TPS in Samarinda. However, temperature should not be interpreted as an independent determinant because food availability, humidity, sanitation, and waste-management practices may also influence fly density.

Temperature category distribution

Table 2. Temperature category distribution at TPS in West Ungaran

Temperature category	Frequency (n)	Percentage (%)
Supportive	19	67.9
High	9	32.1
Total	28	100.0

Most TPS, 19 (67.9%), were classified as having supportive temperatures, while nine (32.1%) were classified as having high temperatures. Thus, more than half of the study sites had temperatures classified by the study criteria as supportive of fly presence. Apriliansyah et al. (2024) noted that fly density may be influenced by sanitation, temperature, lighting, humidity, waste management, and other environmental conditions. Temperature should therefore be interpreted together with other environmental variables.

Humidity category distribution

Table 4. Humidity category distribution at TPS in West Ungaran

Humidity category	Frequency (n)	Percentage (%)
Low	3	10.7
Supportive	20	71.4
High	5	17.9
Total	28	100.0

Most TPS, 20 (71.4%), were in the supportive humidity category. Five TPS (17.9%) were categorized as high and three (10.7%) as low. The predominance of supportive humidity suggests that microclimatic conditions at most TPS could permit fly presence. This condition warrants attention

particularly when accompanied by accumulated organic waste, wet waste, standing water, or poor sanitation.

Fly density

Table 5. Fly density distribution at TPS in West Ungaran

Fly density	Frequency (n)	Percentage (%)
Low	15	53.6
High	13	46.4
Total	28	100.0

Fifteen TPS (53.6%) had low fly density, while 13 (46.4%) had high density. Although the low category was slightly more prevalent, nearly half of the observed sites had high fly density, indicating that flies remain an environmental health concern at some TPS. The previous study in the same area found 12 TPS (42.9%) with high density and 16 TPS (57.1%) with low density. The difference may reflect changes in waste conditions, observation time, temperature, humidity, sanitation, or measurement conditions. The two datasets should not be combined if their observation periods or procedures differed.

Fly density according to temperature

Table 6. Fly density distribution according to temperature category

Temperature category	Low density (n)	High density (n)	Total (n)
Supportive	15	4	19
High	0	9	9
Total	15	13	28

Among 19 TPS with supportive temperatures, 15 had low fly density and four had high density. All nine TPS classified as having high temperature had high fly density. Descriptively, high fly density was more frequently observed at TPS with high temperature. Nevertheless, this pattern cannot be interpreted as a statistically significant association because the study used descriptive analysis and did not perform hypothesis testing. Previous studies similarly emphasize that temperature should be considered together with other environmental and sanitation conditions.

Fly density according to humidity

Table 7. Fly density distribution according to humidity category

Humidity category	Low density (n)	High density (n)	Total (n)
Low	3	0	3
Supportive	12	8	20
High	0	5	5
Total	15	13	28

All three TPS with low humidity had low fly density. Among 20 TPS with supportive humidity, 12 had low density and eight had high density. All five TPS with high humidity had high fly density. Descriptively, high fly density was concentrated in the supportive and high humidity categories. This finding is consistent with Windyaraini et al. (2025) and Herdianti et al. (2025), although humidity alone cannot determine fly density because food sources and physical sanitation conditions also influence fly presence.

DISCUSSION

Overview of the Main Findings

This study aimed to describe fly density characteristics at Temporary Waste Storage Sites (TPS) in West Ungaran, Semarang Regency, based on temperature and humidity conditions. As presented in Table 1, the temperature at the 28 observed TPS ranged from 26.8°C to 31.2°C, with a mean of 29.05°C and a median of 28.6°C. Most TPS (19; 67.9%) were categorized as having supportive temperature conditions, while 9 TPS (32.1%) were categorized as having high temperature conditions (Table 2).

Table 1. Temperature Measurements at Temporary Waste Storage Sites

Temperature (°C)	n	Minimum	Maximum	Mean	Median
Temperature	28	26.8	31.2	29.05	28.6

Table 2. Temperature Category at Temporary Waste Storage Sites

Temperature category	n	%
Supportive	19	67.9
High	9	32.1
Total	28	100.0

The humidity measurements presented in Table 3 ranged from 57% to 84%, with a mean of 70.54% and a median of 67.5%. As shown in Table 4, most TPS (20; 71.4%) had humidity conditions categorized as supportive, followed by 5 TPS (17.9%) with high humidity and 3 TPS (10.7%) with low humidity. These findings indicate that most of the observed TPS had microclimatic conditions that were categorized as supportive for fly activity.

Table 3. Humidity Measurements at Temporary Waste Storage Sites

Humidity (%)	n	Minimum	Maximum	Mean	Median
Humidity	28	57	84	70.54	67.5

Table 4. Humidity Category at Temporary Waste Storage Sites

Humidity category	n	%
Low	3	10.7
Supportive	20	71.4
High	5	17.9
Total	28	100.0

As presented in Table 5, 15 TPS (53.6%) had low fly density, while 13 TPS (46.4%) had high fly density. Although the proportion of TPS with low fly density was slightly higher, the proportion with high fly density was substantial. This finding indicates that fly density remains an important environmental sanitation concern at several TPS in the study area.

Table 5. Fly Density at Temporary Waste Storage Sites

Fly density	n	%
Low	15	53.6
High	13	46.4
Total	28	100.0

Comparison with Previous Studies

The current distribution of fly density differs slightly from the previous assessment in West Ungaran. The previous study identified 12 of 28 TPS (42.9%) with high fly density and 16 TPS (57.1%) with low fly density, whereas the present study identified 13 TPS (46.4%) with high density and 15

TPS (53.6%) with low density. The increase of one TPS in the high-density category indicates variation in fly-density conditions between observation periods.

This variation may be related to differences in waste accumulation, waste composition, sanitation conditions, environmental microclimate, and waste collection practices at individual TPS. Previous studies have similarly demonstrated variation in fly density across waste management facilities, reflecting differences in environmental and sanitation characteristics. Therefore, the findings of the present study contribute additional descriptive information regarding the current condition of fly density at TPS in West Ungaran.

Possible Explanations or Interpretation

The distribution of fly density according to temperature is presented in Table 6. All 15 TPS categorized as having low fly density were located in the supportive-temperature category. Among the 13 TPS with high fly density, 9 were found under high-temperature conditions and 4 under supportive-temperature conditions. This distribution shows that high fly density was more frequently observed at TPS with high temperature conditions.

Table 6. Fly Density According to Temperature Category

Temperature category	Low fly density n (%)	High fly density n (%)	Total
Supportive	15 (78.9)	4 (21.1)	19
High	0 (0.0)	9 (100.0)	9
Total	15 (53.6)	13 (46.4)	28

The distribution should, however, be interpreted descriptively. The study did not conduct statistical testing to determine an association between temperature and fly density. Therefore, the observed distribution cannot be interpreted as evidence that high temperature causes increased fly density. Temperature may represent one of several environmental conditions that coexist with other factors at TPS, including waste accumulation and sanitation conditions.

Table 7 presents the distribution of fly density according to humidity. All 3 TPS with low humidity had low fly density. Among the 20 TPS with supportive humidity, 12 had low fly density and 8 had high fly density. Meanwhile, all 5 TPS with high humidity had high fly density. This pattern demonstrates that high fly density occurred in both supportive and high humidity conditions, with the highest proportion observed in the high-humidity category.

Table 7. Fly Density According to Humidity Category

Humidity category	Low fly density n (%)	High fly density n (%)	Total
Low	3 (100.0)	0 (0.0)	3
Supportive	12 (60.0)	8 (40.0)	20
High	0 (0.0)	5 (100.0)	5
Total	15 (53.6)	13 (46.4)	28

The presence of high fly density under both supportive and high humidity conditions indicates that humidity should not be considered independently when interpreting fly density. The availability of organic waste and other resources at TPS may provide suitable conditions for flies, while temperature and humidity may act as environmental conditions accompanying fly activity. Because these other factors were not quantitatively assessed in this study, their contribution cannot be determined.

Implications of the Findings

The findings have practical implications for environmental sanitation management at TPS. The presence of high fly density at 13 of 28 TPS (46.4%) indicates the need for routine monitoring and

sanitation control. Monitoring fly density should be integrated with observation of temperature, humidity, waste accumulation, and the general cleanliness of TPS.

The results also indicate that environmental monitoring should not focus on a single microclimatic variable. The distribution in Tables 6 and 7 demonstrates that high fly density occurred under different combinations of temperature and humidity. Therefore, sanitation management should consider the overall environmental condition of TPS, particularly the management of organic waste and prevention of prolonged waste accumulation.

Limitations of the Study

This study used a descriptive cross-sectional design; therefore, the findings represent the environmental conditions and fly density observed during the study period and cannot establish causal relationships. The study was also limited to 28 TPS in West Ungaran, so the findings should be interpreted within the context of the study area. In addition, only fly density, temperature, and humidity were assessed. Other factors that may contribute to fly density, such as waste volume, waste composition, frequency of waste collection, sanitation practices, and physical characteristics of TPS, were not quantitatively analyzed.

These limitations do not invalidate the descriptive findings but indicate that the observed distribution should be interpreted as an overview of environmental conditions and fly density rather than evidence of determinants of fly density.

Suggestions for Future Research

Future studies should include additional environmental and sanitation variables, particularly waste volume, organic waste composition, frequency of waste collection, cleanliness, drainage, and physical characteristics of TPS. Analytical or longitudinal studies could also be conducted to examine the relationship between these factors and fly density over different periods. Such research would provide stronger evidence for developing targeted interventions to control fly density at TPS.

CONCLUSION

The 28 TPS in West Ungaran showed temperature ranges of 26.8–31.2°C and humidity ranges of 57–84%. Most TPS were categorized as having supportive temperature (67.9%) and supportive humidity (71.4%). Low fly density was found at 53.6% of TPS, while 46.4% had high density. Descriptively, all TPS with high temperature and all TPS with high humidity had high fly density. These findings indicate that temperature and humidity should be included in routine monitoring of fly density at TPS, while recognizing that the descriptive design does not establish statistical association or causality.

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