

Original Article

Assessment of Fly Density, Temperature, and Humidity in The Port Areas of The Banyuwangi Regency: Implications for Disease Vector Control

Khaidar Ali^{1,2}, Syifa Ula Hamidya^{1*}, Muhammad Addin Rizaldi¹

¹ Department of Public Health, Faculty of Health Sciences, Universitas Jenderal Soedirman, Jl. Dr. Soeparno, Karangwangkal, Karang Bawang, Grendeng, Kec. Purwokerto Utara, Purwokerto, Jawa Tengah 53122, Indonesia; ² Center of Sustainable Development Goals, Universitas Jenderal Soedirman, Gedung LPPM UNSOED Lt. 3, Jl. Dr. Soeparno Karangwangkal, Purwokerto, Jawa Tengah 53122

ABSTRACT

Background: Fly density is a critical indicator of environmental sanitation quality and potential risk of disease transmission in port environments. **Objective:** This study assessed fly density levels, temperature, and humidity in port areas of the Banyuwangi Regency to understand vector distribution patterns and inform disease prevention strategies. **Methods:** A quantitative cross-sectional study was conducted at three port locations in Banyuwangi: Ketapang Port, Tanjung Wangi Port (perimeter area), and landing craft machine ports (buffer areas). Fly density was measured via the fly grill method, according to the Indonesian Ministry of Health guidelines. The temperature and humidity measurements were recorded simultaneously at each location. The kruskal-wallis test was used to compare fly density levels between locations. **Results:** The mean fly densities at waste disposal sites in Ketapang Port, food stalls in Tanjung Wangi Port, and the open dumping area at LCM Port were 9, 9, and 2 flies per block grill, respectively. The average temperatures at the three locations ranged from 29.76°C to 35.53°C, with humidity levels between 62.82% and 77.35%. Statistical analysis revealed significant differences in fly density among the three locations ($p < 0.05$), with the highest mean ranks observed at food stalls in Tanjung Wangi Port. **Conclusion:** The perimeter areas presented high fly density levels that pose substantial public health risks, whereas the buffer area maintained an acceptable fly density. The environmental conditions recorded at all the sites provided optimal breeding conditions for the disease vectors. The implementation of targeted waste management strategies and environmental sanitation interventions is necessary at perimeter locations to mitigate disease transmission risk and protect public health in these transportation hubs.

KEYWORDS

Fly density; port environments; disease vectors; environmental sanitation; waste management; public health; vector control; Banyuwangi

ARTICLE INFO

Received Feb 22, 2025
Revised Apr 15, 2024
Accepted Apr 18, 2024
Online Apr 26, 2024

EDITOR

Prof. Dr. Mahendra Pal
BVSc & AH., MVPH.,
Ph.D., D.Sc.

CORRESPONDENCE

Syifa Ula Hamidya
Department of Public
Health, Faculty of
Health Sciences
Universitas Jenderal
Soedirman,
syifa.hamidya@unsoed.ac.id

CITE THIS ARTICLE

Ali K., Hamidya SU., and Rizaldi MA. (2025). Assessment of fly density, temperature, and humidity in the port areas of the Banyuwangi Regency: Implications for disease vector control. *Svāsthya: Trends in General Medicine and Public Health*, 2(3): e94. <https://doi.org/10.70347/svsthy.v2i3.94> .



Supplemental data for this article can be accessed online at <https://doi.org/10.70347/svsthy.v2i3.94>

©2025 The Author(s). Published with license by PT. Mega Science Indonesia

This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0). This license allows reusers to copy and distribute the material in any medium or format in unadapted form only, for noncommercial purposes only, and only so long as attribution is given to the creator. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

INTRODUCTION

Fly density is a critical indicator of environmental sanitation and public health quality in areas surrounding ports and other industrial zones [1]. High fly densities not only reflect poor hygiene but also signify serious health risks, including the potential transmission of communicable diseases such as diarrhea, dysentery, and cholera [2]. According to Makbul et al. [3], port areas face various environmental challenges, such as waste accumulation, inadequate waste management, and unsanitary open spaces, which create favorable conditions for breeding flies. These factors significantly increase the risk of contamination and pose substantial health threats to both the local community and workers.

As insects are capable of carrying various pathogenic microorganisms on their bodies, flies frequently act as mechanical disease vectors, transmitting pathogens from contaminated organic materials to human food or beverages through direct physical contact [2]. On the basis of the preceding discussion, controlling fly populations in port areas, particularly within the perimeter and buffer zones, is crucial for preventing disease transmission and enhancing environmental sanitation [1]. Efforts to address this issue include waste management and the implementation of fly control measures such as insecticide spraying and the strict closure of waste disposal sites. However, the effectiveness of these interventions relies on consistent monitoring and active participation by the local community surrounding the port [3].

The Ministry of Health classifies vectors into three categories: mechanical, biological, and mechanical-biological [4]. Several diseases, including diarrhea, cholera, shigellosis, skin irritation, and salmonellosis, are transmitted by mechanical vectors, particularly flies. According to Yudhastuti [5], all parts of a fly's body can function as disease transmission agents, with their role in disease spread being primarily mechanical. This occurs when pathogenic organisms adhering to the fly's body, legs, or hair contaminate food upon contact.

The Ministry of Health explains that house flies can transmit a variety of bacteria, particularly enteric bacteria such as bacillary dysentery (*Shigella*), cholera, typhoid, paratyphoid (*Salmonella*), anthrax, and various types of cocci [4]. Flies also serve as vectors for several protozoan parasites, including amoebic dysentery parasites (*Entamoeba* and *Giardia*) and the eggs of certain types of tapeworms. Given these factors, the impact of flies is directly related to public health concerns and warrants further attention.

This study focused on the evaluation of fly density in the port area of the Banyuwangi Regency to support effective environmental management strategies. Flies are recognized as disease vectors commonly found in environments with poor sanitation. They can spread various pathogens that pose significant health risks to humans, as indicated in several studies [6]. This finding is consistent with Andriani's [7] research on restaurant areas, which revealed a correlation between poor sanitation and increased fly density, particularly in locations such as waste disposal sites and wastewater drains. Basic sanitation, including waste management and drainage systems, plays a crucial role in controlling fly populations in public environments such as ports.

Fly density influences the potential occurrence of diarrheal cases in a given area, making it essential to conduct research on fly density in the Ketapang Port area, which is managed by Ketapang Port (perimeter area) and Ketapang Village (buffer area). This is due to the high mobility associated with Ketapang Port, particularly during national holidays, which leads to increased waste production at the port. Additionally, the high mobility at Tanjung Wangi Port, related to cargo transportation, also contributes to the fly density at Ketapang Port, including the buffer area, namely, Ketapang village, which is influenced by activities in the surrounding area.

According to data from the World Health Organization (WHO) and the United Nations International Children's Emergency Fund (UNICEF), approximately 2 billion cases of diarrhea occur annually, with 1.9 million children under the age of five dying from diarrhea, particularly in developing countries such as Southeast Asia. In Indonesia, the 2018 Basic Health Research (Riskesdas) survey reported a diarrhea prevalence of 8% across all age groups, 12.3% among children under five years of age, and 10.6% among infants. According to the 2018 Sample Registration System, diarrhea was the leading cause of neonatal death (7%) and death in infants aged 28 days and older (6%). The impact of diarrhea is closely linked to stunting in infants and young children. Recurrent diarrheal episodes can lead to malnutrition, resulting in stunting. In

2020, diarrhea remained a leading cause of death among children aged 29 days to 11 months (14.5%) and children under five years (4.55%) [8].

This study assessed fly density levels, temperature, and humidity in port areas of Banyuwangi Regency (Ketapang, Tanjung Wangi, and landing craft machine (LCM) ports) to understand vector distribution patterns and inform disease prevention strategies. The findings of this study can serve as a valuable reference for authorized agencies in implementing targeted interventions and control measures to reduce fly density. By addressing environmental sanitation issues, these actions can help mitigate the health risks associated with flyborne diseases and improve public health conditions in port areas.

MATERIALS AND METHODS

Study design and setting

This study employed a quantitative research method. The research was conducted at ports located in Banyuwangi Regency, including Ketapang, Tanjung Wangi, and landing craft machine (LCM) ports, in 2016 (Figure 1). The ports were classified into two categories: the perimeter area (the region located within the port) and the buffer area (the region located outside the port, with a distance ranging from 400 m to 2 km). Ketapang Port and Tanjung Wangi Port, as perimeter areas, are located in Kalipuro District, Banyuwangi, with fundamental differences in port functions. Ketapang Port serves as a transportation hub for water-based transit, such as ferry crossings between Java Island and Bali Island. In contrast, Tanjung Wangi Port is designated for docking and/or anchoring ships that originate from long-distance voyages, such as international vessels and fishing boats. The buffer area in this study is located at the LCM port, which consists of a residential area situated outside the port, with a radius ranging from 200 to 500 m.

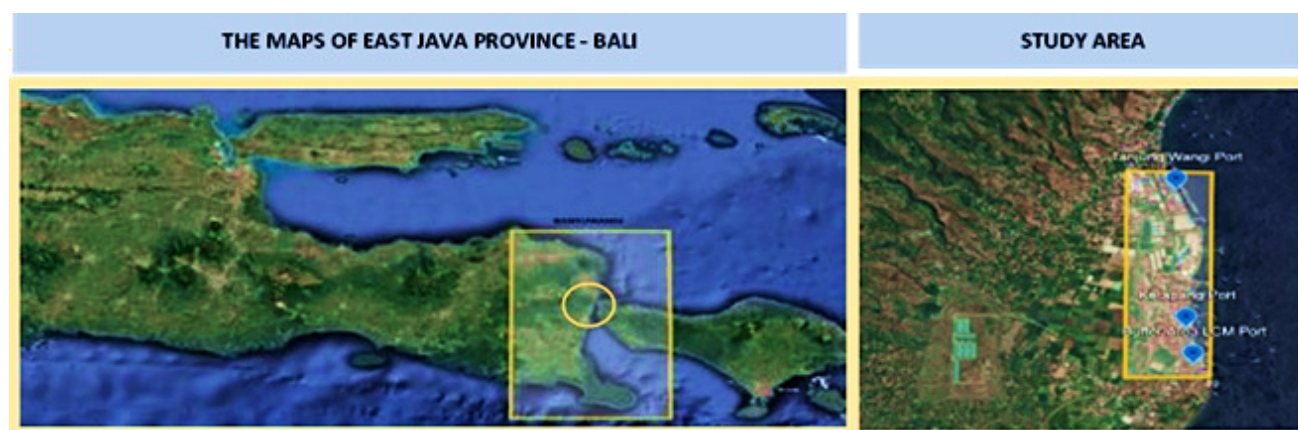


Figure 1. Study area (Ketapang Port, Tanjung Wangi Port, and Buffer LCM port)

Data

The data used in this study were primary data, which were collected directly from the field. The data collected included temperature, humidity, and fly density levels. Data collection was conducted at a single time in April 2016, prior to 09:30 AM local time. The data were gathered at Ketapang Port, Tanjung Wangi Port, and the Buffer Area of LCM Port, specifically at the following locations: the waste disposal site (TPS) at Ketapang Port, the food stall area at Tanjung Wangi Port, and the open dumping area at LCM Port, with 10 measurement points at each location.

Measurements of temperature, humidity, and fly density

Fly density measurements were performed according to the guidelines established by the Indonesian Ministry of Health [9] and the Standard Operating Procedures from the Port Health Office Class II Probolinggo (Banyuwangi). The measurement process began with the preparation of equipment (fly grill, counter, stopwatch) and the mapping of locations with potential fly breeding sites, followed by temperature and humidity measurements at each location or point

and, finally, the measurement of fly density. The temperature and humidity were measured via a thermohygrometer. Fly density was measured by counting the number of flies landing on the fly grill for 30 s, which was repeated 10 times at each location. Fly landings were counted via a counter. The results of the five measurements with the highest total fly count were averaged. The measurement results were interpreted as follows: (a) 0-2 is low (not a concern); (b) 3-5 is moderate (monitoring of fly breeding sites/garbage piles is necessary); (c) 6-20 is high/ dense (control measures are required); (d) >20 is very high (extremely dense population; protection of fly breeding sites and control measures are necessary).

Statistical analysis

Data analysis was conducted via a univariate approach, with the aim of understanding the characteristics of the variables descriptively, without examining the relationships between variables. This study presents data in the form of tables and figures, including frequency distributions and means of the data. A bivariate analysis via the kruskal-wallis test was subsequently employed to compare the fly density levels at Ketapang Port, Tanjung Wangi Port, and the LCM port buffer area. The Kruskal-Wallis test was chosen because the data were not normally distributed. The mean rank values indicate the average rank for each treatment group. The null hypothesis (Ho) was rejected when the p value was < 0.05 (indicating a significant result). This analysis was performed via SPSS, Inc., Armonk, NY, USA, version 23.0. To provide insights into effective vector management in port environments, this study was conducted as a mini-review. Articles related to the environmental management of healthy ports were reviewed to enrich the understanding of the topic.

RESULTS

Temperature and humidity in the perimeter area and buffer area

The Banyuwangi Regency is located in East Java, with geographic coordinates ranging from 7°43' to 8°46' South latitude and 113°53' to 114°38' East longitude. The Banyuwangi Regency is situated at the eastern tip of Java Island. The total area of Banyuwangi Regency is 5,782.50 km², making it the largest region in East Java Province [10]. The results of the temperature measurements at Ketapang Port, Tanjung Wangi Port, and the buffer area of the LCM Port, specifically at the fly density data collection points, are listed in Table 1.

Table 1. Differences in temperature and humidity between the perimeter area and buffer area

LP	Perimeter Area				Buffer Area	
	Ketapang Port		Tanjung Wangi Port		LCM Port	
	T (°C)	HM (%)	T (°C)	HM (%)	T (°C)	HM (%)
1	32.7	69.9	28.7	80.6	34.7	64.3
2	32.5	69.8	29.8	79.2	35.6	62
3	33.2	69.1	29.9	77.1	35	62.9
4	33.3	68.6	29.9	77.7	35.8	61.3
5	33.9	67	29.7	77.3	36	61
6	33.8	66.8	30.2	76.8	35.1	63.2
7	34	68	30.1	76.4	35.1	63.2
8	35.4	64.4	30.1	75.5	36	63.3
9	36.9	59.7	29.8	76.1	35.4	63.3
10	36.6	59.6	29.4	76.8	36.6	63.7
Average	34.23	66.29	29.76	77.35	35.53	62.82

Remarks: LP, Location Points; T, Temperature; HM, Humidity

On the basis of the humidity levels shown in Table 1, the highest humidity levels at Ketapang Port and Tanjung Wangi Port were recorded at points 1 (69.9%) and 1 (80.6%), respectively. The elevated humidity levels observed in the morning at the Ketapang and Tanjung Wangi ports are

attributable to the presence of moisture-laden air masses. These conditions are known to contribute to an increase in humidity when confronted with low temperatures. Additionally, the highest humidity level in the buffer area was recorded at Point 1, with a value of 64.3%. The average humidity levels at the Ketapang, Tanjung Wangi, and LCM ports were 66.29%, 77.35%, and 62.82%, respectively.

Fly density in the perimeter and buffer areas

The results of the fly density measurements at locations in Ketapang Port, Tanjung Wangi Port, and LCM Port, specifically the waste disposal site (TPS) at Ketapang Port, the food stall area at Tanjung Wangi Port, and the open dumping area at LCM Port, are presented in Table 2. As shown in Table 2, the highest number of flies at the waste disposal site was found at points 1, 2, 6, and 8, with nine flies per block grill at each point. The point with the greatest number of flies at the Tanjung Wangi food stall was point 6, with 12 flies per block grill. Additionally, the highest number of flies in the open dumping area of the LCM port was found at points 1, 6, and 7, with a total of two flies per block grill at each point. The average fly densities at the waste disposal site at Ketapang Port, Tanjung Wangi food stall, and the open dumping area at LCM Port were 9 flies per block grill, 9 flies per block grill, and 2 flies per block grill, respectively. The results of the kruskal-wallis test, as shown in Table 2, indicate that the highest mean rank was found at the Tanjung Wangi food stall (21.2), followed by the waste disposal site at Ketapang Port (18.8) and the open dumping area at LCM Port (6.5). Furthermore, the p value was 0.000 ($p < 0.05$), indicating a significant difference.

Table 2. Examination of the perimeter area (Waste Disposal Site at Ketapang Port and Food Stall at Tanjung Wangi Port) and buffer area (LCM Port)

Category	Flygrill Installation Locations	Number of Flies During Installation Interval										Total	Average Fly Density +	Mean Rank*
		1	2	3	4	5	6	7	8	9	10			
Perimeter Area	Waste Disposal Site at Ketapang Port	9	9	3	0	4	9	7	9	8	2	51	9	18.8
	Food Stall at Tanjung Wangi Port	4	5	9	4	10	12	4	5	3	9	65	9	21.2
Buffer Area	Open Dumping Area at LCM Port	2	0	1	1	1	2	2	1	0	0	10	2	6.5
Kruskal-Wallis Test		Assmp. Sig. = 0.000 ($p < 0.05$)												

Remarks: + Fly density was taken from five points with the highest total fly count; * Mean Rank of Kruskal-Wallis Test results (p value < 0.05)

DISCUSSIONS

Diarrhea remains a significant public health issue, particularly in developing regions, because of its strong association with poor environmental sanitation, inadequate personal hygiene, and unhealthy behavior. Studies have shown that high fly densities in unsanitary environments contribute to the transmission of diarrheal pathogens. In port areas, where waste management and sanitation conditions vary, the presence of flies indicates potential health risks. The findings of this study reinforce those of previous studies, demonstrating that fly density is greater in areas with poor waste management, such as food stalls and waste disposal sites. This highlights the need for improved sanitation and targeted fly control measures to mitigate the risk of disease transmission in the future. Studies have also shown that environmental sanitation, personal

hygiene, and healthy behavior are associated with the transmission of communicable diseases [20, 21].

The detection of diarrhea in children under five years of age in Indonesia remains rare. According to data from the Ministry of Health of Indonesia [11], only 22.18% of the targeted cases were identified in 2021. Key challenges include suboptimal program implementation due to changes in management, weak data validation processes, insufficient integration of data across programs, and diversion of resources to address the COVID-19 pandemic. Additionally, logistical shortages, such as limited supplies of oral rehydration salts (ORSs) and zinc, have hindered effective diarrhea management.

Strategies and interventions for addressing diarrhea cases, as outlined by the Ministry of Health [12], include implementing community education initiatives through communication, information, and education (CIE) channels to increase public awareness of diarrhea. Strengthening cross-programme collaboration, such as integrating maternal and child health (MCH), nutrition, surveillance, and environmental health programs, is also emphasized in this strategy. Enhancing the recording and reporting of diarrhea cases, both manually and electronically, is crucial. Partnerships with professional organizations are encouraged to improve the standards of diarrhea management. Furthermore, the strategy highlights the need to enhance logistical support, conduct healthcare worker training, and ensure adequate budget allocation for effective interventions.

The density of flies in the perimeter and buffer areas of ports serves as an indicator of environmental sanitation conditions, which pose a significant risk as potential sources of disease transmission [7]. Studies conducted in various regions, including port environments, have revealed that factors such as inadequate waste management, the presence of organic waste, and humid conditions strongly contribute to the high density of flies [3, 18].

A study conducted at the Port of Indramayu by Makbul et al. [3] demonstrated that locations with inadequate waste management, such as uncovered or poorly maintained waste disposal sites, present higher fly density indices than do sites with proper waste management. This finding aligns with research conducted at Peunayong Market, Banda Aceh, where the accumulation of organic waste in fish-selling areas was associated with increased fly density, particularly that of *Chrysomya megacephala* and *Musca domestica* [1]. Unsanitary habitats, the presence of food remnants, and liquid waste are the primary factors contributing to fly breeding [7]. Houseflies (*Musca domestica*) and blowflies (*Chrysomya megacephala*) were predominantly found in areas with poor sanitation levels. Both species are known to carry pathogens responsible for diseases such as diarrhea, dysentery, and typhoid fever [1].

According to Makbul et al. [3], fly density can be controlled through measures such as insecticide spraying in areas such as ports and traditional markets to reduce fly populations. However, prolonged insecticide use may lead to resistance. Community-based approaches, including maintaining environmental cleanliness, covering waste disposal sites, and involving local communities in waste management, have shown more sustainable outcomes than individual-based approaches. Routine evaluation of fly density is also necessary to ensure the effectiveness of control methods. For example, at the Port of Indramayu, assessments have indicated a reduction in fly density at waste disposal sites with improved waste management practices, although certain locations still fail to meet sanitation standards.

The presence of flies not only compromises environmental aesthetics and comfort but also poses significant public health risks to humans. At the Peunayong fish market, a high fly density has been associated with increased bacterial contamination of food products, potentially leading to disease outbreaks [1]. These findings underscore the importance of proper waste management and systematic fly control to mitigate health risks in port areas. Community-based approaches coupled with periodic sanitation evaluations are essential for establishing healthier and safer port environments.

Adult flies exhibit diurnal activity, particularly from morning to late afternoon. They are strongly attracted to household waste, including food residues, dairy products, processed foods, human and animal feces, blood, and carcasses. Fly density is significantly influenced by resting sites, as the choice of resting location determines their presence in a given area. Sari [13] reported

that flies do not feed during midday but rest on walls, ceilings, grass, and other cool shaded areas. Furthermore, flies prefer locations near food sources and breeding sites sheltered from strong winds and direct sunlight. For example, flies commonly rest on the edges of food containers, electrical wires, and other surfaces and exhibit minimal activity at night. The typical resting heights for flies do not exceed five meters above ground level.

The average temperatures in the perimeter areas of Ketapang and Tanjung Wangi Ports were 34.23°C and 29.76°C, respectively. The average temperature in the buffer area of the LCM port was 35.53°C. The average humidities in the perimeter areas of Ketapang and Tanjung Wangi Ports were 69.3% and 77.35%, respectively. In contrast, the buffer area of the LCM port had an average humidity of 62.82%. These temperature and humidity conditions provide an ideal environment for breeding flies. The measurement of fly density conducted in the perimeter areas of Ketapang Port and Tanjung Wangi Port, as well as in the buffer area of LCM Port, revealed significant variations in fly density. Ketapang Port and Tanjung Wangi Port presented high fly density levels, with an average of 9 flies per block grill, whereas the buffer area of LCM Port presented a low fly density of 2 flies per block grill. Statistical analysis revealed a significant difference in fly density among Ketapang Port, Tanjung Wangi Port, and the buffer area of LCM Port ($p < 0.05$), with the highest mean fly density observed at food stalls in Tanjung Wangi Port.

On the basis of observations, the selected locations for fly density measurements in the perimeter area included the Ketapang Waste Disposal Site (TPS) and food stalls at the Tanjung Wangi Port. The waste disposal site at Ketapang Port is situated adjacent to the Tourist Information Center and consists of three waste containers within a single 4.5 m × 4.5 m site. When constructed from waterproof materials (concrete walls), the TPS lacks proper covering, thereby increasing the potential for the presence of flies. At the waste disposal site at Ketapang Port, the fly density was assessed at 10 sampling points, and the five points with the highest fly counts were selected for further analysis. Points (1, 2, 6, 8, and 9) recorded the fly densities of 9 flies/block grill, 9 flies/block grill, 9 flies/block grill, 9 flies/block grill, and 8 flies/block grill, respectively. The predominant species identified was *Musca domestica* (the housefly). *Musca domestica* is characterized by the presence of four distinct dark longitudinal stripes on the dorsum, in addition to large compound eyes. The breeding sites of *Musca domestica* include human refuse, animal feces, and decaying food. In this study, the prevalence of these species can be attributed to the presence of household waste at the study site.

At the food stalls in Tanjung Wangi Port, located approximately 250 m from the port gate, fly density measurements were conducted at sites with high potential for fly presence, such as dishwashing areas. Among the measured points, locations 6, 5, 3, 10, and 2/8 presented the highest fly counts on the grill. The calculated fly density at the food stalls in Tanjung Wangi Port was determined to be nine flies/block grill, categorized as high. The buffer area in this study refers to the buffer zone at the LCM port, where fly density measurements were conducted in an open dumping area (a community waste disposal site). This site, approximately 5 m² in size, is located adjacent to the ocean. The open dumping area lacks protective structures to mitigate the risks posed by pests and vectors of health hazards, posing potential health risks to nearby residents. The observations identified *Musca domestica* (housefly) as the dominant species in the area.

Adult *Musca domestica* exhibit high activity throughout the day, frequently moving between various food sources. They are particularly attracted to human food items, such as sugar, milk, and other edibles, as well as human feces and blood, contributing to their abundance in these locations. *Musca domestica* is a known vector of bacterial pathogens (typhoid fever, paratyphoid fever, dysentery, and bacterial food poisoning), protozoa (*amoebic dysentery*), viruses (poliomyelitis, trachoma, coxsackie virus, and hepatitis), Q fever, helminths, and cholera [4].

Fly density measurements in the buffer area recorded an average of two flies/block grill, indicating that the fly density in this area was not significant enough to warrant interventions or treatments. On the basis of previous explanations, the study by Sari [14] on fly density at Wage Market, Purwokerto, reported an average fly density classified as high, with 10 flies per block grill. The study further identified factors influencing fly density at the Wage Market, including

poor sanitation conditions, inappropriate waste disposal site placement, and environmental factors such as temperature, humidity, and lighting conditions.

Sugiarto [15] demonstrated that the fly density at the Cikolotok landfill (TPA) ranged from 0–179 flies per 15-min interval per sampling point. The highest density was observed in the waste sorting area, with 528 flies recorded. Similarly, Istiqomah [16] reported no significant differences in *Musca domestica* density across various fly grill colors. The average fly densities, ranked from lowest to highest, were associated with brown, purple, blue, orange, green, gray, red, yellow, and white fly grills. Tarigan [17] highlighted a significant relationship between fly density and the incidence of diarrhea. These findings underscore the importance of implementing fly control measures in areas with high fly densities. The correlation between elevated fly densities and health issues, such as diarrhea, necessitates targeted interventions to mitigate health risks in such environments [18–21].

Public health implications

This study revealed fly density levels in the Banyuwangi Regency port environments, with perimeter areas exhibiting high densities (9 flies per block grill), indicating a significant risk of disease transmission. The environmental parameters documented—temperatures ranging from 29.76°C to 35.53°C and humidity levels between 62.82% and 77.35%—create optimal conditions for *Musca domestica* proliferation. The statistically significant density differences between the perimeter and buffer zones ($p < 0.05$) highlight the influence of waste management practices on vector populations, with uncovered disposal sites and food preparation areas serving as primary breeding grounds. These findings necessitate targeted interventions at identified hotspots, particularly the waste disposal site at Ketapang Port and food stalls at Tanjung Wangi Port, where the mean fly density ranks were the highest. The implementation of proper waste containment infrastructure, regular environmental monitoring, and comprehensive vector surveillance would substantially reduce the risk of disease transmission. Port authorities should establish systematic assessment protocols and community-based prevention strategies to protect transient populations and surrounding communities from vector-borne pathogens transmitted by flies, thereby strengthening regional disease prevention systems in these critical transportation hubs.

Limitations

This study provides valuable insights into fly density levels in port areas, highlighting the impact of environmental factors, such as temperature and humidity, on fly populations. These findings emphasize the need for effective sanitation management and fly control measures to reduce the potential health risks associated with fly borne diseases. These results can serve as a reference for public health authorities to design targeted interventions to improve hygiene in port environments. However, a limitation of this study is that it was conducted in 2016, which means that the results may not fully reflect the current situation. Nonetheless, this study offers a comprehensive analysis of fly density patterns at three ports in Banyuwangi Regency, providing a foundation for future research and environmental health strategies.

CONCLUSIONS

The average temperature and humidity levels in the perimeter and buffer areas were optimal for fly growth and reproduction. The fly density in the perimeter areas, specifically Ketapang Port (8.8 flies/block grill) and Tanjungwangi Port (9 flies/block grill), fell within the high-density category. Therefore, effective fly control measures are necessary to mitigate potential risks in these environments. In contrast, the fly density in the buffer area of the LCM port was classified as low, with an average of two flies/block grill, indicating no immediate need for intervention in this area. These findings underscore the necessity for targeted vector management strategies that prioritize waste disposal sites and food preparation areas within port perimeters. The implementation of proper waste containment systems, regular environmental monitoring, and community engagement in sanitation practices would reduce the risk of mechanical vector transmission. To that end, we recommend establishing systematic fly density surveillance

protocols to evaluate intervention effectiveness and protect public health in these critical transportation hubs, which serve as potential entry points for vector-borne diseases.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTHOR CONTRIBUTIONS

Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, and Supervision: KA, SUH, and MAR.

FUNDING

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGMENTS

The authors thank the stakeholders who supported this study.

REFERENCES

- [1] Rahmayanti R, Erlinawati E, Safwan S. Tingkat kepadatan lalat dan identifikasi jenis lalat pada tempat penjualan ikan di Pasar Peunayong Kota Banda Aceh [Eng. Fly density and identification of fly species at fish markets in Peunayong Market, Banda Aceh City]. *SAGO Gizi Kesehat* 2022;3(2):144-149. <http://dx.doi.org/10.30867/gikes.v3i2.924>.
- [2] Yanti CA, Ediana D, Rizki M. Hubungan perilaku dan tingkat kepadatan lalat dengan kejadian diare di pasar Sarilamak [Eng. Relationship between fly behavior and density and the incidence of diarrhea in Sarilamak market]. *J Human Care* 2018;3(1):1-8. <http://dx.doi.org/10.32883/hcj.v3i1.149>.
- [3] Makbul M, Martini, Wahyuningsih NE. Survei kepadatan lalat di KKP kelas II Bandung wilayah kerja Pelabuhan Indramayu pada Agustus-November 2022 [Eng. Survey of fly density in Class II KKP Bandung working area of Indramayu Port in August-November 2022]. *Bhamada J Ilmu Tek Kesehat* 2023;14(2):89-94. <https://doi.org/10.36308/jik.v14i2.506>
- [4] Kementerian Kesehatan Republik Indonesia. Pedoman Pengelolaan Vektor Penyakit Menular [Eng. Guidelines for the Management of Vector-Borne Diseases]. Jakarta: Kementerian Kesehatan Republik Indonesia. 2011
- [5] Yudhastuti. Pengendalian Vektor dan Rodent [Eng. Vector and Rodent Control]. Surabaya: Universitas Airlangga. 2011
- [6] Kumala YSN, Pawenang ET. Kondisi sanitasi dan kepadatan lalat kantin sekolah dasar wilayah kerja puskesmas Kedungmundu [Eng. Sanitation conditions and fly density in elementary school canteens in the working area of the Kedungmundu Community Health Center]. *J Health Educ* 2017;2(1):99-106. <https://doi.org/10.15294/jhe.v2i1.19118>.
- [7] Andriani U. Hubungan fasilitas sanitasi dasar dengan tingkat kepadatan lalat pada rumah makan di Kecamatan Tanjung Karang Pusat Kota Bandar Lampung [Eng. The relationship between basic sanitation facilities and fly density in restaurants in Tanjung Karang district, Central Bandar Lampung city]. *Ruwa Jurai J Kesehat Ling* 2019;13(2):64-69. <https://doi.org/10.26630/rj.v13i2.2780>
- [8] Kementerian Kesehatan Republik Indonesia. Laporan Kinerja Direktorat Jenderal Pencegahan dan Pengendalian Penyakit Semester I Tahun 2024 [Eng. Performance Report of the Directorate General of Disease Prevention and Control for the First Semester of 2024]. Jakarta: Kementerian Kesehatan RI; 2024.

- [9] Departemen Kesehatan Republik Indonesia. Pengendalian Penyakit dengan Pendekatan Lingkungan [Eng. Disease Control with an Environmental Approach]. Jakarta: Departemen Kesehatan Republik Indonesia. 1991
- [10] Badan Pusat Statistik Kabupaten Banyuwangi. Kabupaten Banyuwangi dalam Angka [Eng. Banyuwangi regency in figures]. Banyuwangi: Badan Pusat Statistik. 2022. <https://banyuwangikab.bps.go.id/en/publication/2022/02/25/4e5ed690c36051962d779bd3/kabupaten-banyuwangi-dalam-angka-2022.html>
- [11] Kementerian Kesehatan Republik Indonesia. Profil Kesehatan Indonesia [Eng. Indonesia Health Profile]. Jakarta: Kementerian Kesehatan Republik Indonesia. 2022. <https://kemkes.go.id/id/category-download/profil-kesehatan>
- [12] Kementerian Kesehatan Republik Indonesia. Rancangan aksi nasional penanggulangan pneumonia dan diare 2023-2030 [Eng. National action plan for the prevention and control of pneumonia and diarrhea 2023-2030]. Jakarta: Kementerian Kesehatan Republik Indonesia. 2023. https://p2p.kemkes.go.id/wp-content/uploads/2023/12/NAPPD_2023-2030-compressed.pdf
- [13] Sari, N. Perilaku lalat terhadap lingkungan [Eng. Fly behavior toward the environment]. Purwokerto: Universitas Jenderal Soedirman. 2013
- [14] Sari, N. Analisis Kepadatan Lalat di Pasar Wage Purwokerto [Eng. Analysis of fly density in Wage Market, Purwokerto]. J Kesehat Mas 2013; 5(2), 25–32.
- [15] Sugiarto, A. The population of flies in cikolotok landfill, Pasawahan District, Purwakarta Regency, Indonesia. J Lingkungan Hidup 2017; 4(1): 15–22. <https://publications.inschool.id/index.php/icash/article/view/809>
- [16] Istiqomah. Pengaruh Warna Fly Grill terhadap Kepadatan Lalat *Musca domestica* [Eng. The Effect of Fly Grill Color on the Density of Musca domestica Flies]. J Kesehat Ling Indones 2008; 2(3), 45–50. <https://doi.org/10.14710/jkli.19.1.21-26>
- [17] Tarigan, R. Hubungan kepadatan lalat dengan kejadian diare di wilayah X [Eng. The relationship between fly density and the incidence of diarrhea in region X. J Epidemiologi 2014; 3(4), 90–98.
- [18] Andhini AN, Ramadhanintyas KN, Abidin Z. Hubungan keberadaan kandang ayam dengan kepadatan lalat di Kecamatan Kawedanan Magetan [Eng. The relationship between the existence of chicken coops and fly density in Kawedanan District, Magetan]. J Ilmiah Ilmu Pendidikan 2022;5(9):3515-3519. <https://doi.org/10.54371/jiip.v5i9.846>
- [19] WHO. Diarrheal disease. Online. Available on: <https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease> (accessed 13 February 2025)
- [20] Ali, K., Rizaldi, MA., Khoiron., Ma'rufi, I. Personal hygiene and healthy behavior toward scabies incidence in Jember regency: A cross-sectional study. Kesmas Indonesia 2025; 17(1):55-69. <https://doi.org/10.20884/1.ki.2025.17.1.13749>
- [21] Ali, K., Rizaldi, MA., Putri, SMD. Environmental sanitation and scabies incidence among santri in Islamic Boarding School in Jember regency. Insights Public Health J. 2024; 5(2):1346. <https://doi.org/10.20884/1.iphj.2024.5.2.13462>