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Analysis of Noise and Odor Around the Putri Cempo Waste-To-Energy (WTE) Plant in Jatirejo Surakarta City Central Java Indonesia

Yanuar Kurnia Romadhoni[1], Dewi Liesnoor Setyowati[2]

[1,2]Department Geography, Faculty of Social and Political Sciences, Universitas Negeri Semarang, Semarang City, Central Jawa, Indonesia.

Corresponding Author: Yanuar Kurnia Romadhoni

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ABSTRACT

This study aims to describe the operational activities of the Putri Cempo Waste-to-Energy (WTE) Plant in Surakarta City and to analyze the community's responses to noise and odor disturbances resulting from its operations. A descriptive quantitative approach was employed, with data collected through structured questionnaires and field observations. A total of 36 respondents participated in the study, selected using a quota sampling technique from three neighborhood units (RT) in the Jatirejo area. The findings indicate that the WTE plant has not yet operated optimally, with an average activity of only 8 days per month due to limited raw material supply. Most respondents reported that the noise and odor disturbances were relatively mild; however, a portion of the community experienced significant discomfort, particularly during the initial phase of full-scale operations. The main sources of disturbance were identified as engine noise and the stench of decaying organic waste, exacerbated by environmental factors such as wind direction and time of day. The data suggest that community responses reflect the presence of noise and odor disturbances in the vicinity of the Waste-to-Energy plant.

Keywords: *Waste-to-energy, noise, odor nuicance*

INTRODUCTION

Waste-to-Energy (WTE) plants have emerged as a critical strategy in addressing the urban waste crisis, including in Indonesia. This technology offers dual benefits by reducing the volume of municipal solid waste while simultaneously generating renewable energy through combustion processes. However, the presence of Waste-to-Energy (WTE) plants near residential areas has raised environmental concerns. Globally, various studies have shown that WTE facilities can be sources of air pollution due to the emission of hazardous compounds such as dioxins, furans, and heavy metals, which can degrade air quality and pose serious health risks to surrounding communities (1). In addition, the process of converting waste into energy also has the potential to increase greenhouse gas emissions if not equipped with an optimal emission control system (2,3). This issue becomes increasingly complex when Waste-to-Energy (WTE) plants are established in densely populated areas that lack sufficient environmental carrying capacity and possess inadequately structured social mitigation systems (4).

There are two other forms of pollution that are often overlooked but have a significant

impact on the quality of life of communities: odor pollution and noise pollution. Waste-to-Energy (WTE) plants have the potential to generate strong odors originating from volatile compounds such as nitrogen and sulfur released during the waste processing stages (5,6). Community complaints related to odor tend to increase in correlation with the proximity of residential areas to waste processing facilities, with odors sometimes detectable within a radius of several kilometers (7,8). The impact of odor is not limited to discomfort; it can also trigger stress and sleep disturbances, ultimately leading to a decline in the quality of life within the affected community (9,10). Complaints related to odor are often difficult to substantiate objectively, which underscores the importance of examining this issue more thoroughly.

On the other hand, noise generated from the operational activities of Waste-to-Energy (WTE) facilities also poses tangible impacts that are often overlooked. Activities such as waste transportation, processing, and energy conversion produce considerable noise levels, which can lead to hearing disturbances and negatively affect the sleep quality of nearby residents (11,12). In urban areas such as Surakarta City, vehicular traffic and dense industrial activities exacerbate the level of noise experienced by the community, particularly among those residing near the Waste-to-Energy (WTE) facility (13). Psychologically, prolonged exposure to noise has also been shown to affect mood and concentration (14,15). Therefore, it is essential to examine noise and odor disturbances concurrently, as both contribute to the overall quality of life of communities living near waste processing facilities.

Community responses to environmental disturbances, such as odor and noise, play a critical role in assessing the extent to which Waste-to-Energy (WTE) facilities are accepted by local communities. Studies have shown that imbalances in risk perception particularly when communities feel excluded from planning and decision-making processes can lead to significant social resistance (16). This perception is strongly influenced by the spatial proximity between communities and pollution sources, as well as by socio-economic factors such as education level and income (17,18). Dalam konteks tersebut, pendekatan survei kuantitatif dengan menggunakan kuesioner terstruktur berbasis skala Likert menjadi metode yang efektif untuk menggambarkan gangguan di masyarakat secara sistematis dan memungkinkan analisis secara statistik (19,20). Such surveys enable researchers to assess public perceptions of environmental pollution caused by Waste-to-Energy (WTE) facilities, particularly in relation to noise and odor generated by their operations.

This phenomenon becomes increasingly relevant when examined within the local context of Surakarta City, particularly in the Jatirejo area, Mojosongo Sub-District, Jebres District. This area is one of the residential zones located in close proximity to the Putri Cempo Waste-to-Energy (WTE) facility. According to data from the Surakarta City Environmental Agency, the volume of municipal waste in Surakarta reached an average of 394,000 tons per day in 2024. Moreover, the Putri Cempo Landfill (locally referred to as TPA), covering approximately 17 hectares, has been declared over capacity since 2010 and has surpassed its designated technical lifespan (21). The majority of incoming waste originates from general municipal solid waste (22). This condition has had adverse impacts, as the Putri Cempo Landfill (TPA) is no longer capable of accommodating the daily waste generated by the community. To address this issue, the Surakarta City Government has planned the development of a Waste-to-Energy (WTE) facility in collaboration with PT. Solo Citra Metro Plasma Power (SCMPP) (21).

This initiative aligns with Presidential Regulation No. 35 of 2018, which mandates the acceleration of Waste-to-Energy (WTE) facility development through the application of environmentally friendly technologies (23). Surakarta is one of the 13 cities included in the National Strategic Project for Waste-to-Energy (WTE) Development. The

Putri Cempo WTE facility is capable of processing up to 545 tons of waste per day using gasification technology, generating up to 8 MW of electricity. Of this, 5 MW will be sold to the State Electricity Company (Perusahaan Listrik Negara, PLN), while the remaining power will be used for operational purposes (21). Surakarta is one of the 13 cities included in the National Strategic Project for Waste-to-Energy (WTE) Development. The Putri Cempo WTE facility is capable of processing up to 545 tons of waste per day using gasification technology, generating up to 8 MW of electricity. Of this, 5 MW will be sold to the State Electricity Company (Perusahaan Listrik Negara, PLN), while the remaining power will be used for operational purposes (24,25). However, to date, few scientific studies have quantitatively and descriptively documented community responses to environmental disturbances caused by the WTE facility.

The Human Ecology Theory provides a relevant conceptual framework for understanding this phenomenon. It emphasizes the dynamic interactions between humans and their surrounding environment, including how individuals respond to environmental stressors such as odor and noise pollution (26,27). In the context of Waste-to-Energy (WTE) facilities, communities residing in close spatial proximity are directly exposed to environmental impacts and tend to adjust their behaviors, perceptions, and coping strategies in response to these conditions (28). Therefore, it is essential to examine the extent to which the intensity of pollution exposure is perceived by the community, and how they assess the risks and impacts associated with the presence of the Waste-to-Energy (WTE) facility in their vicinity.

Based on the above discussion, it is evident that odor and noise pollution from Waste-to-Energy (WTE) facilities is not merely a technical issue but also concerns the broader aspect of community well-being. In the context of sustainable development, there is a need for research that can comprehensively capture public perceptions of such environmental disturbances. Every development project inevitably alters the surrounding environment and the lives of nearby communities. These changes become evident once the facility becomes active and operational. Therefore, each project should take into account both the physical and social dimensions of community life in the affected area (29). This study is expected to provide valuable insights for policymakers, WTE facility operators, and urban planners in formulating more comprehensive environmental mitigation strategies that are responsive to community needs.

Research on the environmental impacts of waste treatment facilities, particularly Waste-to-Energy (WTE) plants, has been conducted using various contexts and approaches. However, most existing studies to date remain focused on technical aspects, such as incineration efficiency, air emissions, and economic assessments. For instance, a techno-economic analysis of waste incineration facilities in Ghana did not incorporate community perceptions or non-material environmental disturbances such as odor and noise (1). Similarly, studies focusing on the health impacts of noise have primarily addressed epidemiological aspects without directly linking them to the operational activities of Waste-to-Energy (WTE) facilities or to the social responses of communities toward noise pollution. (11). Several studies have begun to address socio-environmental issues, such as by developing theoretical frameworks linking social stress and air pollution within the context of vulnerability among low-income communities. However, these studies do not specifically examine the impacts of waste treatment or Waste-to-Energy (WTE) facility operations, nor do they integrate both pollution aspects simultaneously (28). Another study examining odor disturbances in Finland focused solely on public perceptions of odor pollution originating from waste treatment centers, without linking it to noise pollution or the operational context of Waste-to-Energy (WTE) facilities

(8). In Indonesia, a study has explored waste management within the zero-waste framework in Banyumas, with a primary emphasis on community participation and sustainable policy development. However, it did not specifically examine the noise and odor impacts of waste treatment facility operations, let alone assess them quantitatively based on community perceptions (4).

The novelty of this study lies in its integration of two forms of non-material environmental pollution noise and odor analyzed through the lens of local community perceptions. It employs a quantitative approach within the context of an operational Waste-to-Energy (WTE) facility located in a densely populated area of Indonesia (Putri Cempo, Surakarta), a setting that has received limited scholarly attention to date. This research highlights the environmental pressures exerted by WTE activities on affected communities. Accordingly, the objective of this study is to describe the operational activities of the WTE facility and to analyze community perceptions of two non-material environmental disturbances noise and odo resulting from its operations.

MATERIALS & METHODS

This study employed a descriptive quantitative approach, with the research classified as a field survey type (30). This method was employed to describe the operational activities taking place at the Waste-to-Energy (WTE) facility and to analyze the noise and odor generated from those activities. The study was conducted in Jatirejo, Mojosongo Sub-District, Jebres District, Surakarta City. The site was selected due to its geographical proximity, being directly adjacent to the operational area of the Putri Cempo Waste-to-Energy (WTE) facility, known locally as PLTSa Putri Cempo separated only by a road. The Putri Cempo Waste-to-Energy (WTE) is located within the same compound as the Putri Cempo Landfill (TPA), as illustrated in Figure 1.

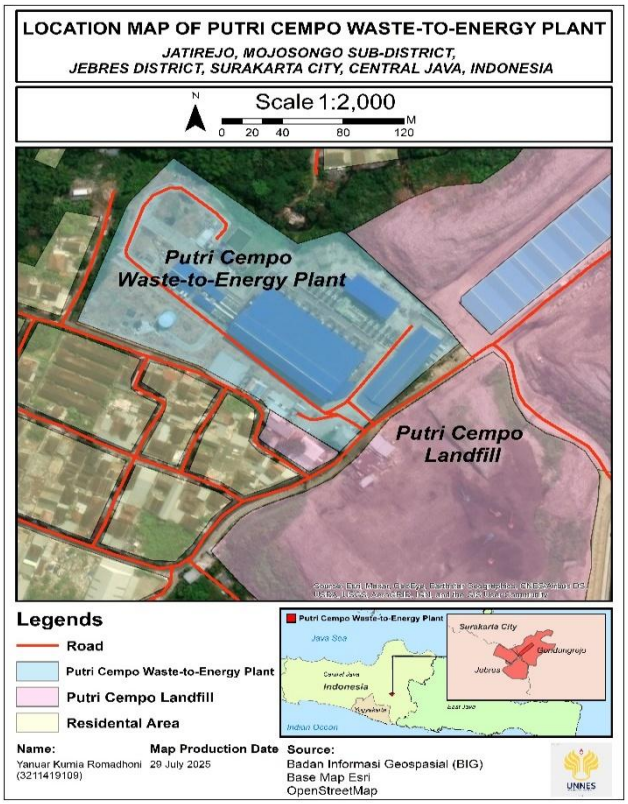

Figure 1. Distance between the Putri Cempo Waste-to-Energy location, the Putri Cempo landfill, and residential areas

Source: Created by the Researcher, 2025

The population in this study consisted of heads of households residing in Jatirejo, Mojosongo Sub-District, Jebres District, Surakarta City. The sample size was determined using Slovin's formula (30) with a margin of error of 0.15. The results are presented in Table 1.

Table 1. Sample Size Determination

Slovin's Formula	Description
$n = \frac{N}{1 + N(e)^2}$	n = Sample Size
	N= Population Size
	e = margin of error (0.15)
$n = \frac{182}{1 + 182(0.15)^2} = \frac{182}{1 + 4.095} = \frac{182}{5.095} = 36$	

From a total of 182 households, a sample of 36 households was selected as respondents. To ensure representation from each neighborhood unit (Rukun Tetangga/RT), quota sampling was employed (30), with sample distribution proportional to the number of households in each RT. The calculation followed the formula: (Number of Households per RT/Total Households)×Total Sample, rounded to the nearest whole number. This method allowed for the proportional allocation of the 36 respondents across the three RTs in Jatirejo, based on the number of households in each unit. The results are presented in Table 2.

Table 2. Distribution of Sample Size per RT Based on Household Proportion

RT	Household Population (HH)	Proportional Sample Allocation	Final Sample
RT 01	98	(98/182) x 36 ≈ 19.39	19
RT 02	50	(50/182) x 36 ≈ 9.89	10
RT 03	34	(34/182) x 36 ≈ 6.72	7
Total	**182 HH**		**36**

The variables examined in this study included the operational activities of the Putri Cempo Waste-to-Energy (WTE) facility, noise, and odor. Data collection techniques comprised field observations, surveys/questionnaires, interviews, and documentation. This study did not employ physical measurement instruments such as a sound level meter or olfactometer, as its primary focus was to quantitatively assess community perceptions of noise and odor disturbances resulting from WTE activities. Community responses were measured using a structured questionnaire, which served as the main approach. Information regarding the facility's operational activities was obtained through direct interviews with the Head of the Putri Cempo Landfill (TPA), as the WTE is located within the same site as the landfill. Additionally, field observations were conducted to allow the researcher to directly observe and identify instances of noise and odor. A four-point Likert scale was used to measure perceived disturbances, with scores ranging from 1 to 4 (30).

STATISTICAL METHODS

The data obtained from the questionnaires were analyzed using descriptive quantitative techniques. To measure the perceived noise and odor disturbances experienced by the community due to activities at the WTE facility, a four-point Likert scale (30), ranging from 1 to 4, was employed for each questionnaire item. The scores provided by each respondent were then averaged and calculated for each indicator (frequency, duration, and intensity), and subsequently categorized using the Likert scale interval formula.

Table 3. Likert Scale Interval Formula

Likert Scale Interval Formula	Category
$interval = \frac{(4-1)}{4} = 0.75$	1.00 - 1.75 = Not Disturbing
	1.76 - 2.50 = Slightly Disturbing
	2.51 - 3.25 = Moderately Disturbing
	3.26 - 4.00 = Very Disturbing

In addition, categorical data such as the time patterns of disturbances, types of noise and odor, and weather conditions during odor exposure were analyzed using descriptive quantitative methods through frequency and percentage tabulation. All data were processed using Microsoft Excel 2021.

RESULT

Operational Activities of the Putri Cempo Waste-to-Energy Facility

ased on interviews conducted with the Head of the Waste Management Unit, the input or waste reception process at the Putri Cempo Landfill (TPA) involves the daily intake of waste originating from Surakarta and surrounding areas, with an average volume of approximately 360-400 tons per day (Surakarta City Environmental Agency data, December 2024) (22). In comparison, the Putri Cempo Waste-to-Energy (WTE) facility has the capacity to process up to 545 tons of waste per day for energy conversion (21).

Figure 2. Putri Cempo Landfill, known locally as TPA Putri Cempo
Source: Field Documentation by Researcher, 2025

Various types of waste entering the Putri Cempo Landfill (Figure 2), including metal, glass, wood, and plastic, are first sorted. The types of waste accepted by the Waste-to-Energy (WTE) facility are limited to household organic and easily processed non-organic waste, excluding materials such as metal, glass, and rubber, which must be separated due to their incompatibility with gasification technology. The process then advances to the energy treatment and conversion stage. The sorted waste is sun-dried to reduce its moisture content, then shredded and mixed with a bio-activator to accelerate the drying process until the moisture content falls below 20%. Afterward, the waste is fed into a gasification chamber to produce synthetic gas, which is then used to power a diesel engine connected to a generator to produce electricity. In the final output stage, the Putri Cempo WTE facility has a production capacity of up to 8 megawatts (MW), with approximately 5 MW sold to the national electric utility (PLN), and the remaining used for the facility's own operational needs. However, over the past two months, daily operations have not reached optimal performance due to limited feedstock availability. As a result, the facility's operating schedule has been adjusted accordingly. According to the Head of the Putri Cempo Landfill, the WTE facility was operational for only 8 days within a 30-day period.

Surrounding Area of the Putri Cempo Waste-to-Energy Facility

During the observation period, the facility was not in operation, and therefore no emissions were observed from the smokestack. Due to limited visibility of the smokestack and restricted access to the Putri Cempo WTE facility, the researcher was unable to enter the site to directly inspect or document the smokestack. The absence of visible emissions indicated that the facility was not operating at full capacity during the visit. Given these limitations in visibility and access, as shown in Figure 3, the researcher was only able to capture visuals of the facility from outside the premises.

Figure 3. One of the Putri Cempo Waste-to-Energy (WTE) Facility Units (Exterior View)
Source: Field Documentation by Researcher, 2025

As shown in Figure 4, along the access road leading to the Putri Cempo Landfill (TPA) and Putri Cempo Waste-to-Energy (WTE) facility, only minimal waste spillage was observed from garbage transport vehicles passing over the weighbridge to unload waste at the landfill site. However, standing water was found near the entrance to the weighbridge area leading into the Putri Cempo Landfill (TPA) and WTE facility.

Figure 4. Puddles and Minor Litter Scattering
Source: Field Documentation by Researcher, 2025

Nevertheless, the level of dust observed in the residential area was not significant enough to obstruct visibility. Dust was primarily seen adhering to residents' walls and surrounding foliage. Additionally, vegetation in the area appeared to be growing, although plant coverage was relatively sparse. A visual observation of one of the nearby vegetation areas is presented in Figure 5.

Figure 5. Vegetation around facility
Source: Field Documentation by Researcher, 2025

During the observation, animals were found around the WTE and Putri Cempo Landfill facilities, including a herd of cattle near the WTE site. The number of these animals appeared to be relatively high. This condition is depicted in Figure 6.

Figure 6. Cattle Found Near the Waste-to-Energy (WTE) and Landfill Facilities
Source: Field Documentation by Researcher, 2025

The cleanliness conditions in the residential area varied considerably. While some sections of the roads and drainage channels appeared to have minimal litter, numerous sacks were still found along the roadsides and in residents' yards. To support these findings, the researcher documented the conditions, as shown in Figure 7.

Figure 7. Road and Drainage Cleanliness Conditions
Source: Field Documentation by Researcher, 2025

Observations of residents' social activities indicated that the community continues to engage in outdoor activities. Children were seen flying kites and running around in residential areas located adjacent to the Putri Cempo Landfill. This suggests that open spaces are still actively utilized, despite their proximity to the waste processing facility.

Field documentation in Figure 8 illustrates how community activities persist even in areas surrounding the and WTE facility at Putri Cempo.

Figure 8. Children Engaging in Outdoor Activities
Source: Field Documentation by Researcher, 2025

Pungent odor was identified as the most dominant environmental disturbance during the observation period. The strongest odor detected by the researcher did not originate from the direction of the Putri Cempo Waste-to-Energy (WTE) facility commonly reported by local residents as resembling a burning smell likely because the facility was not operational at the time of observation. Instead, the most prominent odor emanated from the towering piles of waste at the Putri Cempo landfill, characterized by a strong scent of rotting garbage. The odor intensity was particularly high in close proximity to the landfill. Additionally, odors from nearby poultry farms were also detected, although they remained within tolerable levels. At times, the stench of decaying waste was noticeable even before the researcher entered the observation area, likely due to strong winds carrying odors from the Putri Cempo landfill beyond its immediate vicinity. Throughout the observation period, odors from the direction of the Putri Cempo Waste-to-Energy (WTE) facility reported by several residents as resembling burnt material were rarely detected. This was presumably because the facility was not operational during the observation, and as such, the researcher was unable to identify or describe the specific odors emitted by the WTE facility. The frequency of odor originating from the landfill was relatively high during the observation period, although its duration varied depending on wind direction. At certain moments, the odor was fleeting and dissipated quickly; at other times, it lingered and became noticeably disruptive. The timing of odor emissions from the Putri Cempo landfill was unpredictable, occurring in the morning, afternoon, or evening. Weather conditions also influenced odor intensity whether during rainfall, hot weather, or strong winds blowing from the direction of the landfill.

Analysis of Noise and Odor Disturbances

Table 4. Frequency, Duration, and Intensity of Noise and Odor Disturbances from the Putri Cempo Waste-to-Energy (WTE) Facility

Category	Noise		Odor	
	Number of Respondents	Percentage	Number of Respondents	Percentage
Very Disturbing	7	19.44%	5	13.89%
Moderately Disturbing	10	27.78%	10	27.78%
Slightly Disturbing	17	47.22%	15	41.67%
Not Disturbing	2	5.56%	6	16.67%
Total	36	100.00%	36	100.00%

Based on Table 4, which presents indicators of exposure frequency, exposure duration, and the intensity of noise and odor disturbances, the majority of respondents reported experiencing disturbances at a level categorized as slightly disturbing. A total of 47.22% of respondents indicated that noise from the WTE facility was slightly disturbing, while 41.67% reported a similar level of disturbance from odor. Only a small proportion of respondents felt severely disturbed by noise (19.44%) or odor (13.89%). These findings suggest that, although the WTE is not yet operating at full

capacity, its presence still poses a potential environmental nuisance to nearby residents, particularly in the form of noise and odor. Therefore, even though the current level of disturbance is not considered high, greater attention should be given to the potential increase in disturbances if the facility begins operating at full capacity in the future.

Table 5. Time Patterns of Noise and Odor Disturbances from the Putri Cempo Waste-to-Energy (WTE) Facility

Time of Day	Noise		Odor	
	Respondents	Percentage (%)	Respondents	Percentage (%)
Morning	7	19.44%	7	19.44%
Afternoon	5	14.89%	10	27.78%
Evening/Night	13	36.11%	8	22.22%
Unspecified Time	11	30.56%	11	30.56%
Total	36	100.00%	36	100.00%

As shown in Table 5, the indicators related to the time patterns of noise and odor disturbances reveal important insights. Among the total of 36 respondents surveyed, 13 individuals (36.11%) reported that noise disturbances were most frequently experienced during the evening or nighttime hours, followed by unspecified times (30.56%). This suggests that noise is often perceived during periods when residents are typically at home or resting. In contrast, for odor disturbances, the highest proportion of respondents (30.56%) reported experiencing disturbances at irregular times. This finding indicates that odors from the WTE facility do not occur on a fixed schedule, but rather depend on specific environmental conditions, such as wind direction or particular operational activities at the facility. Therefore, while noise and odor disturbances exhibit different temporal exposure patterns, both types of disturbances can disrupt the comfort and daily life of nearby residents, particularly during periods of rest or routine activities.

Table 6. Types of Noise and Odor Disturbances at the Putri Cempo Waste-to-Energy (WTE) Facility

Disturbance	Type of Disturbance Reported	Number of Respondents	Percentage (% of 36 Respondents)
Noise	1. Machinery Noise	18	50.00%
	2. Heavy Vehicle Noise	10	27.78%
	3. Booming/Impact Sounds	15	41.67%
	4. Steam Hissing Sounds	11	30.56%
	5. Other	9	25.00%
Odor	1. Wet/Organic Waste Odor	19	52.78%
	2. Burning Smell	10	27.78%
	3. Acidic/Chemical Odor	3	8.33%
	4. Other	8	22.22%

Based on Table 6, which presents the types of noise disturbances, it is important to note that respondents were allowed to select more than one option, thus the cumulative percentage may exceed 100%. From a total of 36 respondents, the most frequently reported disturbance was machinery noise, selected by 18 respondents (50.00%). This was followed by booming or impact sounds, chosen by 15 respondents (41.67%), steam hissing sounds by 11 respondents (30.56%), heavy vehicle noise by 10 respondents (27.78%), and other types of noise by 9 respondents (25.00%). These findings indicate that the most frequently perceived sources of noise among residents predominantly originate from the operational activities of the Waste-to-Energy (WTE) facility, even though the facility is not yet operating at full capacity. Several respondents who selected the "other" category clarified that the disturbances they

experienced primarily came from sources outside the WTE facility, such as the noise generated by garbage trucks passing through residential areas.

Meanwhile, based on Table 6, regarding the indicator of odor disturbance types, the most frequently perceived odor was that of wet/organic waste, selected by 19 respondents, accounting for 52.78% of the total. This was followed by a burning smell, reported by 10 respondents (27.78%), other types of odors by 8 respondents (22.22%), and acidic or chemical odors by 3 respondents (8.33%). These findings indicate that the most commonly perceived odor by the community is the smell of organic waste, which aligns with residents' accounts stating that during the drying process of organic waste at the Waste-to-Energy (WTE) facility, a strong odor often disperses into the surrounding environment. In addition to the drying process, similar odors also originate from the waste piles at the Putri Cempo landfill. Other disturbing smells were reported to come from nearby poultry farms located within the residential area. These observations confirm that odor emissions stem from multiple sources in the surrounding environment and are not solely attributable to the incineration process at the WTE facility.

Table 7. Weather Conditions During Odor Exposure

Weather Condition When Odor Was Detected	Number of Respondents	Presentase
Hot and Sunny	9	25.00%
After Rainfall	6	16.67%
Wind Blowing from the WTE Facility	13	36.11%
Not Affected by Weather	8	22.22%
Jumlah	36	100.00%

Based on Table 7, the weather condition indicator reflects the distribution of respondents' perceptions regarding how specific weather factors influence the emergence of odor from the WTE facility. Among the 36 respondents surveyed, 13 individuals (36.11%) stated that the odor was most frequently detected when strong winds blew from the direction of the WTE facility. In relation to wind direction, the odors most commonly reported by residents during such conditions included smells associated with the drying process and, occasionally, the scent of burnt materials. These findings suggest that wind direction plays a significant role in transporting odors from the facility to nearby residential areas. At present, the Waste-to-Energy (WTE) facility has not yet operated at full capacity; therefore, greater attention should be directed toward the potential disturbances that may arise when the facility reaches full-scale operation in the future.

DISCUSSION

Interview findings and document analysis indicate that the Putri Cempo Waste-to-Energy (WTE) facility has the capacity to process up to 545 tons of waste per day and generate approximately 8 megawatts (MW) of electricity. However, according to the Head of the Putri Cempo landfill, the facility has not operated optimally in recent months due to limited availability of feedstock. On average, the WTE has only been operational for eight days per month. This helps explain why the levels of disturbance reported in the questionnaire tend to fall within the mild to moderate range. Although the WTE was inactive during the observation period, questionnaire data still suggest that the facility presents a potential albeit limited environmental nuisance. When the WTE initially began operating at full capacity for 24 hours following its inauguration in 2023, several residents reported significant disturbances, particularly in the form of hissing steam, mechanical noise, and loud pounding sounds. In addition, some community members also reported

perceiving burnt odors carried from the direction of the WTE.

This condition remains understandable, as the WTE was in the early stages of operation and still required several adjustments. In other words, the current decline in disturbance intensity is likely due to the facility's suboptimal operation. It can thus be inferred that if the WTE resumes full 24-hour operation, the level of disturbances perceived by the surrounding community may increase beyond the current baseline.

Based on the tabulated results, the indicators of frequency, duration, and intensity of noise disturbances show that most selected respondents perceived only slight disturbances (47.22%). However, 7 respondents (19.44%) reported that the noise was highly disruptive, which may be attributed to the fact that the WTE is not yet operating at full capacity. The most commonly reported type of noise was machinery noise (50.00%), followed by pounding sounds (41.67%) and hissing steam (30.56%).

The pattern of noise disturbance was most frequently reported during the late afternoon or evening hours (36.11%), which coincides with residents' typical rest periods at home, making the noise from the WTE more noticeably disruptive. This finding is consistent with the study conducted by Passchier-Vermeer (11), which states that exposure to industrial noise can lead to sleep disturbances. In this context, the sounds of machinery, hissing steam, and pounding noises from the WTE are the primary sources of disturbance experienced by the community, even though the facility is currently not operating at full capacity functioning only eight days per month.

Based on the tabulated results for the indicators of frequency, duration, and intensity of odor disturbance, a total of 15 respondents (41.67%) reported being only slightly disturbed. The most commonly perceived odor was that of wet or decomposing organic waste (52.78%). The primary sources of this odor are likely twofold: first, the odor produced during the drying process of organic waste when the WTE operates to convert waste into energy; and second, the odor originating from the accumulation of waste at the Putri Cempo Landfill (TPA). Field observations confirmed that the strongest odor was most frequently detected near the waste piles at the landfill, rather than from the WTE itself, which at the time was not operating at full capacity.

Environmental factors such as wind direction and hot weather were found to amplify the intensity of odors when the WTE is active. A total of 36.11% of respondents indicated that odors were most noticeable when strong winds blew from the direction of the WTE. This finding suggests that odor dispersion is influenced by external factors and does not occur consistently throughout the day. This condition aligns with previous studies which have shown that odor exposure is often affected by meteorological conditions (8).

Another commonly reported odor was a burnt smell. However, since the WTE was not operational during the observation period, its contribution to this odor could not be fully confirmed. Nevertheless, the community continues to regard the WTE as one of the perceived sources of odor, particularly when the facility is in operation.

According to Gerald and Stern's theory of Human Ecology (26,27), the odor and noise disturbances experienced by the residents of Jatirejo represent environmental stressors originating from the activities of the WTE. These disturbances are shaped by the residents' lived experiences of residing near the facility since it began operating. Such disturbances also serve as critical indicators for assessing community perceptions of the WTE as a waste-to-energy management facility. Without appropriate mitigation strategies, these conditions may escalate into environmental conflicts as the WTE's operational activities intensify in the future. In the absence of physical measurement instruments, this study underscores the importance of capturing residents' perceived disturbances to better understand the local community's condition and vulnerability.

CONCLUSION

This study indicates that the Putri Cempo Waste-to-Energy (WTE) facility has the capacity to process up to 545 tons of waste per day, with the potential to generate 8 MW of electricity. However, based on interviews with the head of the Putri Cempo landfill and field observations, the facility has operated an average of only eight days per month over the past two months. This suggests that the operational activities of the WTE plant have not yet reached optimal performance, primarily due to the limited availability of feedstock for energy conversion. Although the facility was not running at full capacity during the data collection period, community accounts noted that disturbances were more pronounced during its initial full-scale operation following its inauguration in 2023 particularly in the form of engine noise and windborne odors resembling decaying organic waste and burnt materials. These findings suggest that, if not properly managed, the WTE facility's operations may continue to pose nuisance risks to nearby residents in the future, especially in the Jatirejo area, which lies in close proximity to the facility..

The analysis indicates that despite the WTE Putri Cempo not operating at full capacity, its associated noise and odor disturbances are still perceived by the surrounding community. Regarding noise, 17 respondents (47.22%) reported experiencing slight disturbances, while 7 respondents (19.44%) described the disturbances as highly disruptive, particularly during the evening and nighttime hours, which coincide with typical periods of rest. The primary sources of noise were identified as machinery hum and mechanical pounding occurring during active operation of the facility. In terms of odor, 15 respondents (41.57%) noted being slightly disturbed, with the most dominant odor identified as that of wet or decomposing organic waste (52.78%), attributed to the drying process within the WTE as well as the accumulation of waste at the Putri Cempo landfill. This was followed by reports of burnt odors (27.78%). External environmental factors such as wind direction and weather conditions were found to influence both the intensity and timing of odor perception. Even when the facility is not fully operational, the community continues to experience environmental stressors emanating from it. According to human ecology theory, community responses to noise and odor disturbances reflect adaptive processes in response to environmental changes. This aligns with the perspectives of Gerald and Stern, who suggest that interactions between humans and their environment prompt specific behavioral or attitudinal responses as mechanisms for coping with ecological pressures induced by activities such as those of the WTE.

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