Original Research Article

Social Impact of Odor Induced by Municipal Solid Waste Treatment Facilities in Ho Chi Minh City

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ABSTRACT

Landfills are mostly used to manage solid waste in Ho Chi Minh City, Vietnam. Due to inappropriate administration, there have been numerous issues over the years relating to odor and leachate. The purpose of this study is to explore the impact of odor stemming from Da Phuoc landfill site on surrounding areas. A questionnaire survey was administered through face-to-face interviews with 409 residents living in the affected areas. The findings of this study indicate that the odor perception of residents significantly influences their attitudes towards waste disposal sites. The results show that odor affects not only the region around municipal solid waste (MSW) but regions more than 7 km away as well. The obtained data indicates that the odor emanating from the MSW disposal site negatively affects the daily life of many residents. This study is an effort to finding a solution to reduce the impact of odor generated from the landfill site on nearby residential areas.

Keywords: Odor perception; landfill site; municipal solid waste; Vietnam

1. INTRODUCTION

Municipal solid waste (MSW) management centers have an adverse impact on the environment [1,2,3]. They contaminate the environment in two main ways: (i) contaminated gas and metals seep into the air, water, and soil from the degradation and treatment of wastes; (ii) garbage disposal causes many problems like noise, litter, dust, vermin, odor, and damage to productive agriculture and historic sites. Therefore, evaluating the influence of MSW management on the environment is a critical task. This task is challenging as many factors such as odor dispersion on nearby landscape, meteorology, and atmosphere, the residence size and educational level of the residents, and weather per season need to be considered.

Gas emissions from the MSW, such as bacteria, odor, and particles, can significantly disturb the neighboring inhabitants. Hence, a few studies on the odor effect of MSW centers were carried out in many territories such as the US, Europe, Japan, and Korea. Qualitative evaluation of the odor effects on residences is often performed by using survey questionnaires to give a standardized assessment [4,5,6,7]. Recently, some surveys targeted three critical points, including the odor effect on health, wellbeing, and how the odor effects are influenced by residents' recognition.

However, such studies have not been conducted intensively in Ho Chi Minh City (HCMC), Vietnam, where the waste degradation is much faster and has a more significant impact on the environment due to the tropical weather. HCMC is the largest city in the south of Vietnam, not only in terms of population but also economy. The HCMC population was

approximately 8,444,600 people in 2017, living within an area of 2,061.2 km^2. The HCMC residents produce 8,175 tons of solid waste per day that contains 6,700-7,000 MSW with 1.02 kg/capita/day [8]. The amount of MSW annually increases by 98,338 tons. A significant portion of the MSW originates from households, schools, hotels, and restaurants. The MSW treatment in the HCMC is mostly landfilling. Around 86% of the solid waste is treated at the two main landfills, Da Phuoc and Phuoc Hiep, and the remaining 14%, which mainly consists of paper, plastic, and metal, is recycled. Unfortunately, the MSW treatment at the HCMC centers, especially in the area shown in Fig. 1, currently causes many environmental consequences such as leachate and bad odor. However, these consequences have not been adequately addressed in order to find solutions for them.

Human reactions to the odors are subjective and changeable. The odor perception is influenced by several personal factors (such as awareness, sensitivity, ability to cope, and previous experience with odors). Personal perception also has a connection to other environmental stressors, socio-economic conditions, and disruption in the activities of residents [9,10]. Moreover, the responses of people are influenced by the characteristics of the odor, such as frequency, intensity, duration, and odor quality [9]. The odor dispersion, concerning odor emissions, wind direction, topography, weather conditions, and the distance from odor sources, affects the load of the environmental odor in a particular area [11,12,13].

Residences close to the waste disposal area probably have broader concerns about the health and environmental impacts [14]. There is a growing awareness of the environmental impact of MSW disposal facilities. Additional reported evidence of the effects on the health of MSW management zones could result in an increased perception of the risk to nearby zones [15]. Therefore, the public's concerns, perceptions, and attitudes about the MSW treatment play an essential role in the final decision on the plant and the location of a new SWM facility [16,17]. When given sufficient information on the possible impacts and benefits of new MSW facilities on the environment, residents readily support their construction [17]. Otherwise, they raise a strong opposition which cannot be avoided [18].

Besides, the effects of distance to hazardous waste sites have been studies in developing countries. Non-sanitary waste treatment centers were classified into two different groups: (i) those within 50 meters of residences and (ii) those outside 50 meters of residences in a site in Sierra Leone [19]. In their study, Al-Khatib el at. (2014) asked the interviewees whether they were opposed to the building of a MSW management facility within one kilometer of their homes [20]. Another questionnaire study examined how interviewees, living within and beyond 250 meters of a dump site in Nigeria, perceived the health impacts of solid waste dumping [21]. The effect of the distance and the changes in the perception of communities through the distance of a site were investigated in Thailand [22]. The results of this study indicate that younger people are more interested in the impact of the sites than elderly respondents, and respondents with higher education are more aware of the impact.

Furthermore, the distance of the living area from the sites has a significant influence on how much the odors of landfills impact the residents. A study addressed the concerns of the poor communities living near the landfill in Hanoi, Vietnam [23]. Their findings indicated that financial compensation should be paid to residents living within a 1 km radius of the landfill instead of only within a range of 500 m, as referenced in a policy applicable in Japan. This study suggests that environmental law in Vietnam should allow residents to join the process of landfill siting in order to have a better understanding of their concerns related to the surrounding landfills. However, previous studies have not focused on the maximum distance of perceived odor or the odor irritation reported by the communities surrounding MSW management facilities. Therefore, the objective of this study is to investigate the odor effects

with regard to the concerns and perceptions of the residences in the HCMC, as well as the residents' attitudes and reactions to the waste treatment facilities in the HCMC by distance.

2. MATERIALS AND METHODS

2.1 Characteristics of the MSW facility

The study area is described in Fig. 1. The Da Phuoc waste treatment facility was built in 2007 in the southeast area of the HCMC. This waste treatment facility was designed with three functions: (i) a recycling processing plant with advanced technologies, (ii) a composting plant, and (iii) sanitary landfilling. The waste treatment facility receives 5,200 tons of waste every day.

2.2 Study area

The questionnaire survey was conducted through face-to-face interviews with households in the four areas located near the waste treatment site, with a distance of less than 3 km (area 1), 3-5 km (area 2), 5-7 km (area 3), and over 7 km (area 4) from the border of the waste disposal facility. As shown in Fig. 1, area 1 is located in the Da Phuoc commune of Binh Chanh District, area 2 is located in the Nhon Duc commune of Nha Be District, area 3 is located in the Phuoc Kien commune of Nha Be District, and area 4 is located in Phu My Ward of Phu My Hung urban area (district 7).

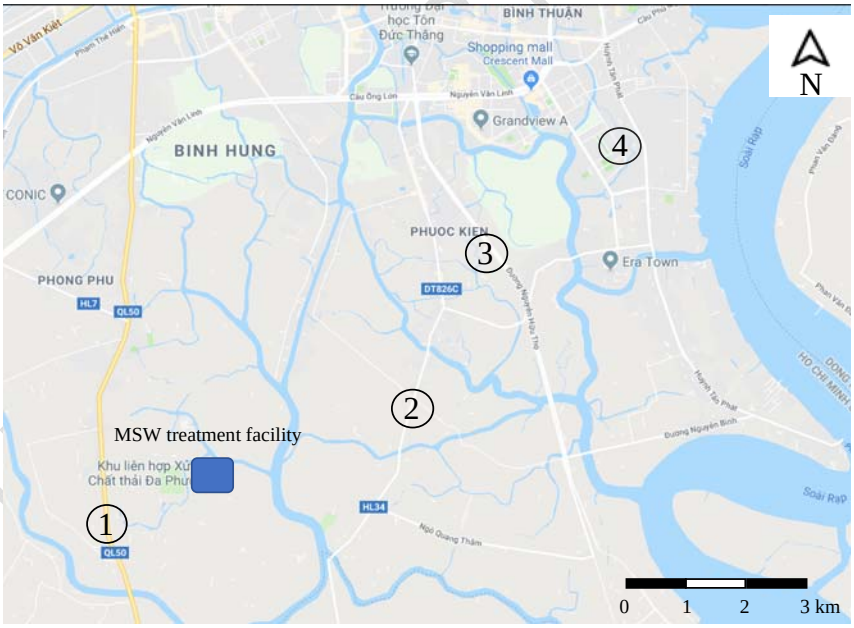

Fig. 1. Location of study area. Source: Google map.

2.3 Data collection and analysis

The survey questionnaire consists of 7 main sections. The questionnaire structure is shown in Fig. 2. These factors include the general perception of environmental pollution (Q1-Q3), perception of odors (Q4-Q13), health (Q14-Q17), assessment of the impact of daily life activities (Q18-Q23), people's actions to cope with odors (Q24-Q28), attitudes towards MSW facilities (Q29-30), and questions regarding demographic status. Questions 1-3 focus on the general perception of environmental pollution: “Are there any pollution-related issues in your residential area?” (yes, no, don’t know); “If yes, what is the principal source?” (industrial activity, landfill site, vehicular traffic, construction activity); and “What problems do you face?” (odor, noise, dust/gas emission from vehicles, flies, others). Questions 4-13 are concerned with the odor perception; “time of year the odor becomes worse,” “frequency, duration, type of odor,” “odor level,” “factors affecting odor emission,” and “intensity of odor emission.” Questions 14-17 are concerned with health issues that include the following aspects: “concerns” about odor, “health affected,” and “symptoms” at the time the respondents noticed the odor. Questions 18-23 cover the annoyance felt by residents due to the odor affecting their daily life in “daily activities,” “studying/working,” “business activity,” and “outdoor activities” (not at all, a little bit, moderately, very, extremely). Questions 24-28 are concerned with the residents’ reactions to the odor emission posed in the fourth part. Information is thus collected with respect to “measures to reduce odor effects,” “used face mask for outdoor activities” (yes, no), “inform government staff about odor problem,” “inform landfill manager about odor problem,” and “if respondents were to move, would they move” (to another location in this area, to another location outside this area, don’t know). The survey was conducted from October to December, 2018. A total of 409 samples were collected, which consisted of 82, 70, 112, and 145 samples corresponding to areas 1, 2, 3, and 4, respectively.

Comment [B1]: What % of the total population was covered? What type of sampling was used? Justify the rationale for both

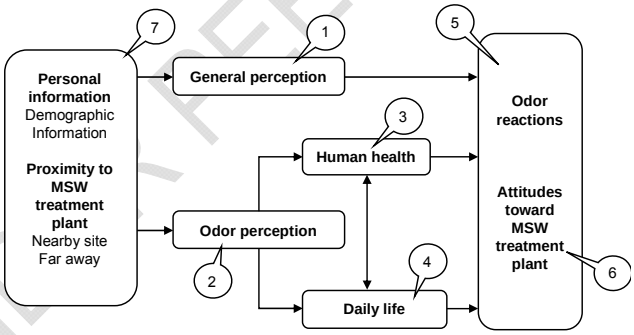

Fig. 2. Hypothetical diagram of cause–impact structure

Chi-square test was performed to test significant relationships between questionnaire components. Factor analysis was used to investigate the correlation between variables and find latent factors. All the analysis were performed in SPSS 25 and MS Excel sofwares.

3. RESULTS AND DISCUSSION

3.1 Demographic profile

The socio-demographic profile results of the respondents are described in this section. There is no significant difference between the number of male and female respondents. In terms of the level of education, the people residing in a region over five kilometers from the MSW treatment facility have a higher education level (undergraduate degree or above), as compared to the people within a five-kilometer range. Respondents over the age of 30 accounted for 85.8%. In respect to the number of years the respondents have lived in an area, 50% of the respondents stated that they had been living in area 1 for over 10 years. On the other hand, more than 50% of respondents from areas 2, 3, and 4 stated that they had been living there for less than 5 years. With regard to the type of dwelling, the results show that 90.2% and 80% of the respondents of areas 1 and 2, respectively, lived in detached houses. Meanwhile, 67.9% and 69% of the respondents of areas 3 and 4 lived in apartments.

3.2 Odor perception

The human nose is able to recognize odors at a lower concentration than gas chromatography for some elements [24]. Odor perception depends on several conditions such as atmospheric conditions, subjective awareness, and influence of different odors [25,26,27]. The one also depends on the personal physical state [28]. In this subsection, the overall results of the questions concerning odor perception, such as frequency, duration, level, intensity, and factors affect odor emission are discussed. We found that odor perception was influenced by wind direction and seasonal changes in the study area. These results revealed that 46.2%, 33.3%, and 20.5% of the respondents noticed that the worst odor occurs from June to August, from September to November, and from March to December, respectively. The respondents stated that odors become worse by distance to the landfill site, depending on the time of year, as shown in Fig. 3. It may explain that the studied area, which has a tropical monsoon, has two typical weather characteristics that directly influence the odor dispersion. The first one is the high temperature throughout the two distinct seasons: the dry season from November to April and the rainy season from May to October. The second one is the wind direction, which changes from month to month: (i) Southeast or in the southern direction from January to May, (ii) West or Southwest direction from June to September, and (iii) Northeast direction from October to December. Due to the change in the wind direction, it is easy to understand why a part of the respondents agreed that the odors became worse from June to November.

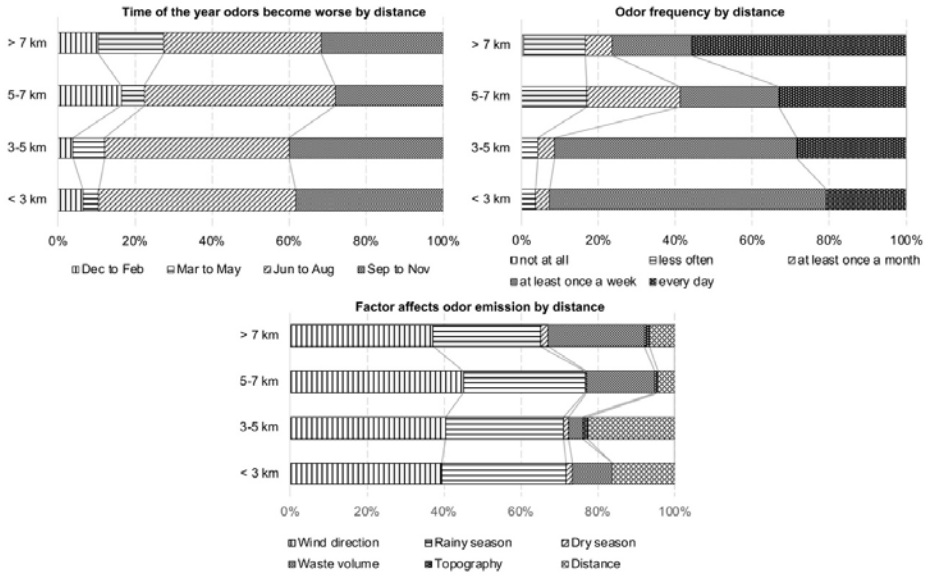

Fig. 3. Odor perception: time of the year odors become worse by distance, odor frequency by distance, factor affects odor emission by distance (Source: compile from field survey 2018)

The odor frequency of "at least once a week" ranked the highest (39.6%), followed by "every day" (33.3%), "less often" (11.7%), "at least once a month" (10.5%), and "not at all" (0.2%). For odor duration, the results indicated that the highest rank was "1–4h" (32.5%), followed by "30 min–1h" (26.2%), "> 4h" (24.7%), "10–30 min" (13.9%), and "< 10 min" (2.7%). The impact of the odor frequency by distance to the landfill site is shown in Fig. 3. The most affected factor was wind direction (40.1%), followed by rainy season (30.1%), waste volume (16.8%), distance (10.7%), dry season (1.4%), and topography (0.7%). During the survey, 41.8% of interviewees reported that they felt "extremely annoyed" by the odor, and 57.7% reported that the intensity of odor had increased over the past two years. Furthermore, 63% of respondents reported that the odor type was offensive. The impact factors of the odor emission by distance to the landfill site is shown in Fig. 3.

3.3 Annoyance of daily life and human health effects

Odor emission from MSW treatment facility potentially adopts a negative effect on human health [29,30]. Odor level strongly influences the relationship between exposure and annoyance. It also affects the association between exposure and symptoms [9]. The previous studies indicated that odor causes a large number of complaints from the community related to industrial [31,32]. It is suggested that odor annoyance instead of perception causes symptoms [33]. The characteristic odor contributes to the formation of annoyance, resulting in headache, respiratory problems, eye, nose and throat symptoms, nausea, etc. The results of this study are consistent with previous studies. In particular, the results showed that a majority of the respondents (86.1%) thought that the MSW treatment facility reduced their quality of life. Their daily activities, business activities, studying or working activities, and outdoor activities were "extremely" affected, accounting for 47.9%, 38.4%, 44.3%, and 56%, respectively. The concerns regarding daily life activities by distance

to the landfill site is indicated in Fig. 4. Around 53.3% of respondents “extremely” expressed their feelings towards the odor. The results indicate that up to 82.9% of the respondents had health-related concerns, and 84.6% of them reported that the odor affected their entire family. The symptoms that people encountered were predominantly nausea (15.7%) and shortness of breath (15.5%). The odor concerns of respondents by distance to the landfill site is shown in Fig. 5.

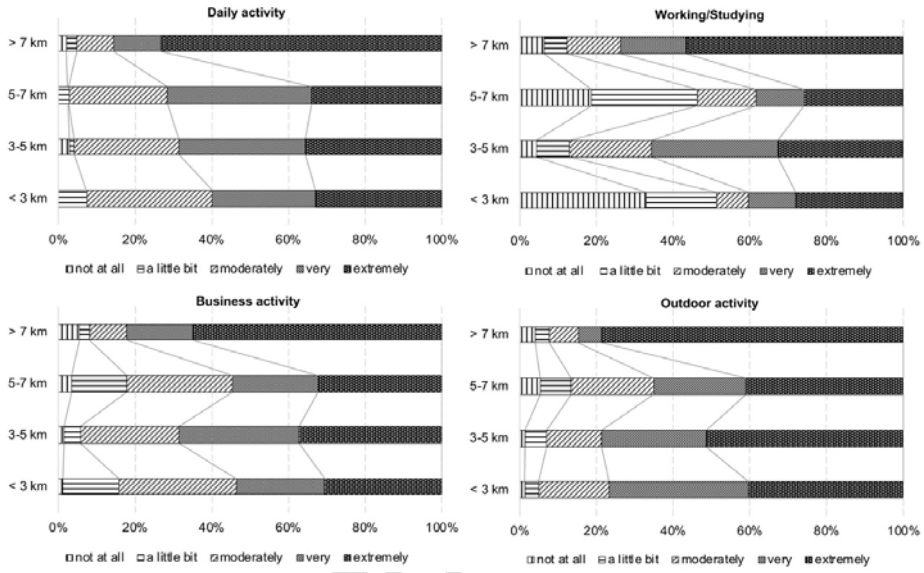

Fig. 4. Daily life concerns (Source: compile from field survey 2018)

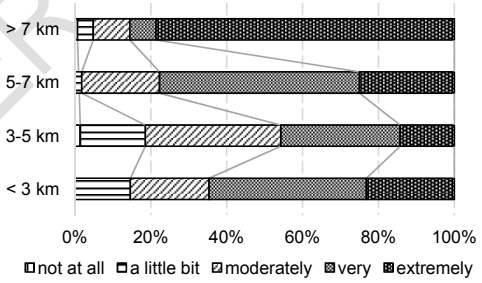

Fig. 5. Odor concern by distance (Source: compile from field survey 2018)

It is clear to say that the odor effects decrease due to increasing distance [22,34,35]. However, the results of this study show that people felt more annoyed in zone 4, as seen in Fig. 5. This might be because the odor dispersion is from MSW management facility to zone 4 (cluster of high-rise buildings). Odor dispersion does not occur in lower floors of the high-rise building areas because the wind speed is proportional to the height of the buildings [36]. In the meantime, odor dispersion is easier on the higher floor due to high wind speed.

Therefore, odor effect does not decrease within this area. The above observation can be explained by residents' awareness, educational level, and dwelling type. Because differences of demographics and lifestyle may generate changes of reactions to environmental odors except at very high or very low concentrations [37,38]. It is possible that the respondents of area 1, due to being exposed to the odor perpetually, may have gotten used to it since long-term exposure of odors may lead to decrease the ability to detect them [39]. The concerned ones are mostly farmers and workers who have to earn money for a living. Meanwhile, most respondents in area 4 have higher incomes and are interested in environmental issues. They also are worse at detecting odors, which leads to aversion and negative behaviors when they detect odors [28].

3.4 Odor reactions and attitudes toward MSW management facility

Perception of odor does affect what response that odor probably evokes, and, on the contrary, odors induce changes in behavior and feeling when a person believe to smell them despite their presence [40,41,42,43]. Table 1 indicates the results of the people's reaction towards the waste treatment facility. About 58% of the respondents close their windows when they notice the odor, while 0.3% (2 out of 409) of them leave their home for a while. A total of 74.8% of people use masks when they need to go outside and 60.6% of respondents inform the government staff about the odor impacts. Also, 21.8%, 12%, and 5.6% of respondents answered "plan to inform," "not inform," and "no idea." Regarding the question of informing the landfill manager about the odor impacts, 49% of respondents selected "inform," followed by 28.1%, 18.8%, and 3.2% of respondents who selected "plan to inform," "not inform," and "no idea," respectively.

Table 1. Odor reactions

Items	Frequency (%)
Used a face mask for outdoor activities	
Yes	306 (74.8)
No	96 (23.5)
Don't know	7 (1.7)
Inform government staff	
Inform	248 (60.6)
Plan to inform	89 (21.8)
Not inform	49 (12.0)
No idea	23 (5.6)
Inform landfill manager	
Inform	204 (49.9)
Plan to inform	115 (28.1)
Not inform	77 (18.8)
No idea	13 (3.2)

The results relating to people's attitude towards the waste treatment facility are shown in Table 2. When asked about the merits and demerits of the waste disposal site, a majority of respondents rated "bad" (67.2%) while only 21% of them rated "good." Also, 52.3% of the respondents stated that the assessment result of the management of the garbage disposal facility is "very bad."

290 **Table 2. Attitude towards MSW management facility**
291

Items	Frequency (%)
Positive or negative aspects	
Good	86 (21.0)
Bad	275 (67.2
Don't know	48 (11.7)
Landfill management rating	
Very good	2 (0.5)
Good	11 (2.7)
Fair	64 (15.5)
Bad	118 (28.9)
Very bad	214 (52.3)

292
293 **3.5 Relationships between the cause – impact structure**
294
295 A series of chi-square tests were implemented to determine significant relationships between
296 the questionnaire components. The inter-connected lines of questionnaire sections in Fig. 6
297 imply the characteristics of their relationship. Significant relationships were observed
298 between the residents' daily life and their odor-related reactions and attitudes towards the
299 MSW treatment plant via chi-square tests. The solid lines in Fig. 6 indicate these
300 relationships. Moreover, there is an insignificant relationship between the odor level of the
301 odor perception section and the distance to the landfill site of the demographic status
302 section. The round dotted line represents the relationship between the two sections
303 mentioned above. Furthermore, the square dotted lines were used to denote significant
304 relationships of residents' odor perception, daily life, odor reactions, and attitudes towards
305 MSW treatment plant with human health. That is because only two questions regarding
306 human health (odor concern and health affected) were correlated with those sections.
307 Finally, there is an insignificant relationship between residents' general perception and
308 demographic profile, odor reactions, and attitudes towards the MSW treatment plant. The
309 long dashed-dotted lines denote the relationships.
310
311 Fig. 7A shows the relationship between odor frequency and the residents' annoyance levels
312 in daily affairs. The results revealed that residents' annoyance is strongly related to the odor
313 frequency. The result of the relationship between residents' annoyance and their given rating
314 of the landfill site is shown in Fig. 7B. The respondents who experienced extreme
315 annoyance poorly evaluated the landfill site.
316

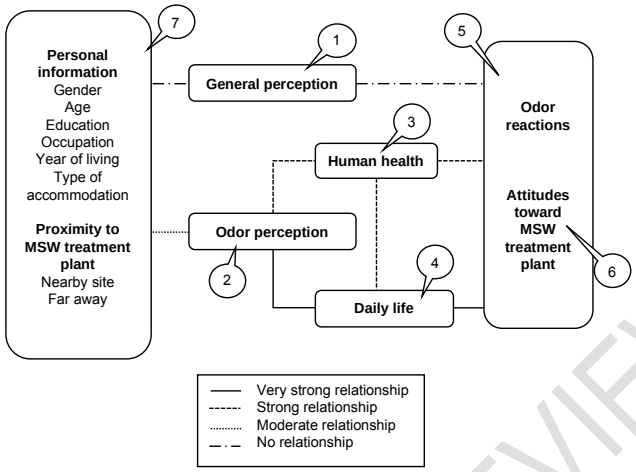

Fig. 6. The relationship between questionnaire parts

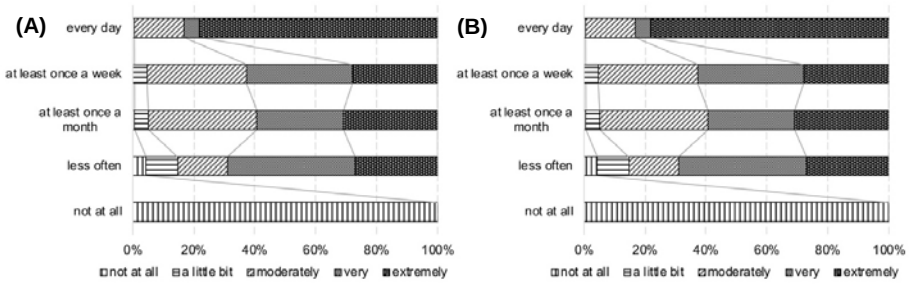

Fig. 7. Relationship between odor frequency and residents' annoyance of daily activity (A), and relationship between residents' annoyance of daily activity and rating of landfill (B) (Source: compile from field survey 2018)

3.6 Factor analysis

Factor analysis was used to explore the potential structure of the variables in questions 1-30, based on the correlation criteria. It is used to discover, validate, and compare the number of factors in the research model with the actual data. The purpose of this analysis is to investigate the correlation between variables and find key factors for future research. In the exploratory factor analysis, the extraction method used is the Principal Component Analysis method and Varimax rotation method with Kaiser Normalization. As a result, there are four components shown in Table 3.

343 **Table 3. Component loadings of concerned items by factor analysis (N=197)**
344

Item	Component			
	1	2	3	4
Work or studying	0.86	0.29	0.04	0.11
Business activities	0.82	0.17	0.03	0.04
Daily activities	0.78	0.37	0.05	0.11
Outdoor activities	0.78	0.32	0.08	-0.03
Worried about the odor	0.77	0.30	0.04	0.16
Property value	0.69	0.16	0.08	0.05
Odor frequency	0.64	-0.03	0.20	0.08
Used a face mask for outdoor activities	0.59	-0.14	0.02	-0.14
Positive or negative aspects	0.30	0.73	0.02	-0.08
Landfill management rating	0.32	0.71	0.09	0.21
Deterioration of environmental quality	0.03	0.65	0.30	0.07
Inform landfill manager	0.11	0.07	0.87	0.00
Inform government staff	0.11	0.21	0.82	0.08
Odor intensity	0.21	-0.12	0.01	0.85
More odor or more sensitive	-0.10	0.28	0.08	0.79
Eigenvalue	5.79	1.75	1.34	1.08

345
346 The first component is named “nuisance” due to the high loadings, including the annoyances
347 of “work/studying,” “business activity,” “daily activities,” “outdoor activities,” “odor frequency,”
348 “worried about odor impact,” “property value,” and “used a face mask for outdoor activity.”
349 “Attitudes toward MSW treatment facility” is the second component that consists of “positive
350 or negative aspects,” “landfill management rating,” and “deterioration of environmental
351 quality.” “Action to cope with odor impacts” is the third component consisting of “inform
352 landfill manager” and “inform government staff.” The fourth component is termed “perception
353 of odor intensity,” which includes “odor intensity” and “more odor or more sensitive.”
354
355 The standard error of regression (REGR) factor score 1 and 2 by distance, the standard
356 error of REGR factor score 1 and 3 by distance, the standard error of REGR factor score 1
357 and 4 by distance, and the standard error of REGR factor score 3 and 4 by distance are
358 indicated in Fig. 8. The results showed that respondents in area 4 (> 7 km) had a higher
359 awareness of perception of odor intensity and attitude toward MSW treatment facility than
360 other regions in terms of a nuisance as seen (Fig. 8A, 8B). Meanwhile, respondents in zone
361 2 had the lowest results of the nuisance, attitude toward MSW treatment facility, perception
362 of odor intensity, and action to cope with odor impacts as seen Fig. 8.

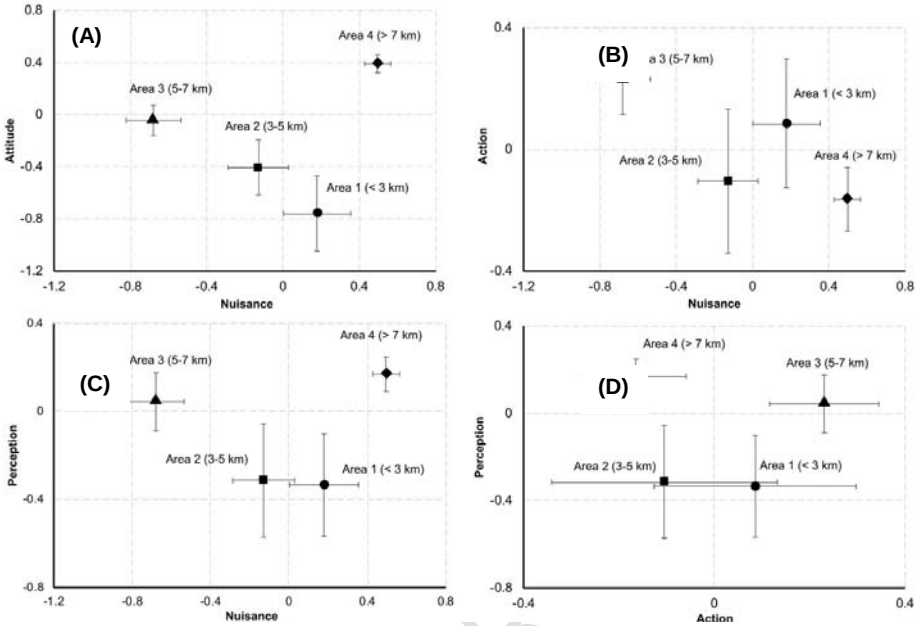

Fig. 8. The standard error of REGR factor scores: nuisance and attitude (A), nuisance and action, nuisance and perception (C), action and perception by distance (D) (Source: compile from field survey 2018)

4. CONCLUSION

In this study, we have investigated the impact of the odor emission on the residents as well as their perceptions, reactions, and attitudes towards the MSW treatment facility. There are several findings which have been observed in our study. Firstly, it can be seen that residents' attitudes toward the landfill site are strongly influenced by their perception about odor. This perception is affected by weather conditions, such as seasonal wind and rain. Secondly, it is found that not only are the area near the MSW management facility influenced by the odor effects but also areas more than 7 km away. In other words, most residents living more than 7 km away from the landfill site felt more annoyed than those living less than that. Thirdly, the collected data provide insights into how the odor from the MSW disposal site negatively changes the residents' daily life. Particularly, the respondents who experienced more annoyance tend to poorly evaluate the landfill site. This is a good start to find solutions for odor improvement in order to reduce its impact on residences. Finally, four principal components have been obtained by using factor analysis. They are identified as "nuisance," "attitudes towards MSW treatment facility," "reactions to deal with odor impact," and "perception of odor intensity." The combination of questionnaire survey and measurement of odor can be considered in future research to achieve greater efficiency in assessing the impact of odor on the community.

ETHICAL APPROVAL

This work was approved by Tokyo Institute of Technology Research Ethics Committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist**.**

REFERENCES

Comment [B2]: Cite more recent references and discuss your results accordingly

1. El-Fadel M, Findikakis AN, Leckie JO. Environmental Impacts of Solid Waste Landfilling. *J Environ Manage*. 1997;50(1):1-25. doi:10.1006/JEMA.1995.0131
2. Lisk DJ. Environmental effects of landfills. *Sci Total Environ*. 1991;100(C):415-468. doi:10.1016/0048-9697(91)90387-T
3. Rabl A, Spadaro J V., Zoughaib A. Environmental impacts and costs of solid waste: a comparison of landfill and incineration. *Waste Manag Res*. 2008;26(2):147-162. doi:10.1177/0734242X07080755
4. Sarkar U, Hobbs SE. Odour from municipal solid waste (MSW) landfills: a study on the analysis of perception. *Environ Int*. 2002;27(8):655-662. http://www.ncbi.nlm.nih.gov/pubmed/11934115. Accessed May 10, 2019.
5. Sarkar U, Longhurst PJ, Hobbs SE. Community modelling: a tool for correlating estimates of exposure with perception of odour from municipal solid waste (MSW) landfills. *J Environ Manage*. 2003;68(2):133-140. doi:10.1016/S0301-4797(03)00027-6
6. Johnson BN, Sobel N. Methods for building an olfactometer with known concentration outcomes. *J Neurosci Methods*. 2007;160(2):231-245. doi:10.1016/j.jneumeth.2006.09.008
7. Hayes JE, Stevenson RJ, Stuetz RM. Survey of the effect of odour impact on communities. *J Environ Manage*. 2017;204:349-354. doi:10.1016/j.jenvman.2017.09.016
8. Verma RL, Borongan G, Memon M. Municipal Solid Waste Management in Ho Chi Minh City, Viet Nam, Current Practices and Future Recommendation. *Procedia Environ Sci*. 2016;35:127-139. doi:10.1016/J.PROENV.2016.07.059
9. Sucker K, Both R, Winneke G. Adverse effects of environmental odours: Reviewing studies on annoyance responses and symptom reporting. *Water Sci Technol*. 2001;44(9):43-51.
10. Nimmermark S. Odour influence on well-being and health with specific focus on animal production emissions. *Ann Agric Env Med 2004, 11, 163–173*. 2004;3(3):163-173. doi:10.24189/ncr.2018.040
11. Che Y, Yang K, Jin Y, Zhang W, Shang Z, Tai J. Residents' concerns and attitudes toward a municipal solid waste landfill: Integrating a questionnaire survey and GIS techniques. *Environ Monit Assess*. 2013;185(12):10001-10013. doi:10.1007/s10661-013-3308-y
12. Sakawi Z, Sharifah, Mastura SA, Jaafar O, Mahmud and M. Community Perception of Odor Pollution from the Landfill. *Res J Environ Earth Sci*. 2011;3(2):142-145. https://pdfs.semanticscholar.org/5aae/5ccc25f7b06d9cb5158158a43a6229166ec7.pdf. Accessed May 10, 2019.
13. Naddeo V, Zarra T, Oliva G, Chiavola A, Vivarelli A. Environmental Odour Impact Assessment of Landfill Expansion Scenarios: Case Study of Borgo Montello (Italy). *Chem Eng Trans*. 2016;54:73-78. doi:10.3303/CET1654013
14. Aatamila M, Verkasalo PK, Korhonen MJ, et al. Odour annoyance and physical symptoms among residents living near waste treatment centres. *Environ Res*.

2011;111(1):164-170. doi:10.1016/j.envres.2010.11.008
15. Vrijheid M. Health effects of residence near hazardous waste landfill sites: a review of epidemiologic literature. *Environ Health Perspect*. 2000;108 Suppl(Suppl 1):101-112. doi:10.1289/ehp.00108s1101
16. Al-Yaqout AF, Koushki PA, Hamoda MF. Public opinion and siting solid waste landfills in Kuwait. *Resour Conserv Recycl*. 2002;35(4):215-227. doi:10.1016/S0921-3449(01)00111-2
17. De Feo G, De Gisi S, Williams ID. Public perception of odour and environmental pollution attributed to MSW treatment and disposal facilities: A case study. *Waste Manag*. 2013;33(4):974-987. doi:10.1016/j.wasman.2012.12.016
18. Rahardyan B, Matsuto T, Kakuta Y, Tanaka N. Resident's concerns and attitudes towards Solid Waste Management facilities. *Waste Manag*. 2004;24(5):437-451. doi:10.1016/j.wasman.2003.11.011
19. Sankoh FP, Yan X, Tran Q. Environmental and Health Impact of Solid Waste Disposal in Developing Cities: A Case Study of Granville Brook Dumpsite, Freetown, Sierra Leone. *J Environ Prot (Irvine, Calif)*. 2013;04(07):665-670. doi:10.4236/jep.2013.47076
20. Al-Khatib IA, Ajlouny H, Al-Sari' MI, Kontogianni S. Residents' concerns and attitudes toward solid waste management facilities in Palestine: A case study of Hebron district. *Waste Manag Res*. 2014;32(3):228-236. doi:10.1177/0734242X14521684
21. Felicia Babs-Shomoye1 RK. *Namakemono Ga Miteta. 2*. Vol 2. Shūeisha; 2004. http://www.jphdc.org/index.php/jphdc/article/view/81. Accessed May 10, 2019.
22. Srangsriwong A, Olapiriyakul S, Yenradee P. Asia - Pacific Journal of Science and Technology Factors influencing public perception and impact distance of a municipal solid waste dumpsite in Thailand. 2018:1-13.
23. Tuan NQ, MacLaren VW. Community concerns about landfills: A case study of Hanoi, Vietnam. *J Environ Plan Manag*. 2005;48(6):809-831. doi:10.1080/09640560500294228
24. Rappert S, Müller R. Odor compounds in waste gas emissions from agricultural operations and food industries. *Waste Manag*. 2005;25(9):887-907. doi:10.1016/j.wasman.2005.07.008
25. R. Noble,* P. J. Hobbs, A. Dobrovin-Pennington, T. H. Misselbrook and AM. Atmospheric Pollutants and Trace Gases. 2001;(i):760-767.
26. Davoli E, Gangai ML, Morselli L, Tonelli D. Characterisation of odorants emissions from landfills by SPME and GC/MS. *Chemosphere*. 2003;51(5):357-368. doi:10.1016/S0045-6535(02)00845-7
27. Gallego E, Soriano C, Roca FX, Perales JF, Alarcón M, Guardino X. Identification of the origin of odour episodes through social participation, chemical control and numerical modelling. *Atmos Environ*. 2008;42(35):8150-8160. doi:10.1016/j.atmosenv.2008.08.004
28. Dalton & Dilks. *ODOR, ANNOYANCE AND HEALTH SYMPTOM IN A RESIDENTIAL COMMUNITY EXPOSED TO INDUSTRIAL ODORS*. South Camden Citizens in Action. 1997; 1–21.
29. Luginaah IN, Martin Taylor S, Elliott SJ, Eyles JD. Community reappraisal of the perceived health effects of a petroleum refinery. *Soc Sci Med*. 2002;55(1):47-61. doi:10.1016/S0277-9536(01)00206-4
30. Elliott SJ, Cole DC, Krueger P, Voorberg N, Wakefield S. The power of perception: Health risk attributed to air pollution in an urban industrial neighbourhood. *Risk Anal*. 1999;19(4):621-634. doi:10.1023/A:1007029518897
31. Harrison EZ, Oakes SR. *Features INVESTIGATION OF ALLEGED HEALTH INCIDENTS ASSOCIATED WITH LAND APPLICATION OF SEWAGE SLUDGES*. Vol 12.; 2002. http://cwmi.css.cornell.edu/Sludge/Newsolutions.pdf. Accessed June 18, 2019.

32. Wakefield S, Elliott SJ. Environmental risk perception and well-being: effects of the landfill siting process in two southern Ontario communities. *Soc Sci Med*. 2000;50(7-8):1139-1154. doi:10.1016/S0277-9536(99)00361-5
33. Cavalini PM. Industrial odorants: The relationship between modeled exposure concentrations and annoyance. *Arch Environ Health*. 1994;49(5):344-351. doi:10.1080/00039896.1994.9954985
34. Furuseth OJ, Johnson MS. Neighbourhood attitudes towards a sanitary landfill: a North Carolina study. *Appl Geogr*. 1988;8(2):135-145. doi:10.1016/0143-6228(88)90029-X
35. Aatamila M, Verkasalo PK, Korhonen MJ, et al. Odor annoyance near waste treatment centers: A population-based study in Finland. *J Air Waste Manag Assoc*. 2010;60(4):412-418. doi:10.3155/1047-3289.60.4.412
36. Chen YC, Bundy D, Hoff S. Modeling the variation of wind speed with height for agricultural source pollution control. *ASHRAE Trans*. 1998;104(Pt 1B):1685-1691.
37. Bliss PJ, Schulz TJ, Senger T, Kaye RB. Odour measurement - factors affecting olfactometry panel performance. *Water Sci Technol*. 1996;34(3-4-4 pt 2):549-556. doi:10.1016/0273-1223(96)00595-1
38. Dalton P. Odor perception and beliefs about risk. *Chem Senses*. 1996;21(4):447-458. doi:10.1093/chemse/21.4.447
39. Dalton P, Wysocki CJ. The nature and duration of adaptation following long-term odor exposure. *Percept Psychophys*. 1996;58(5):781-792. doi:10.3758/BF03213109
40. Schiffman SS, Sattely Miller EA, Suggs MS, Graham BG. The effect of environmental odors emanating from commercial swine operations on the mood of nearby residents. *Brain Res Bull*. 1995;37(4):369-375. doi:10.1016/0361-9230(95)00015-1
41. Knasko SC, Gilbert AN, Sabini J. Emotional State, Physical Well-Being, and Performance in the Presence of Feigned Ambient Odor1. *J Appl Soc Psychol*. 1990;20(16):1345-1357. doi:10.1111/j.1559-1816.1990.tb01476.x
42. Knasko SC. Ambient odor's effect on creativity, mood, and perceived health. *Chem Senses*. 1992;17(1):27-35. doi:10.1093/chemse/17.1.27
43. Rotton J. Basic and Applied Social Psychology Affective and Cognitive Consequences of Malodorous Pollution. 1983;(February 2015):37-41. doi:10.1207/s15324834basp0402