

# Determining the Safe Distance of the Waste Collection Site in Housing Areas of Thai Nguyen Province in Vietnam

Dao Dang Quang, Nguyen Tien Duc

**Abstract** — At the the waste collection site there are many different kinds of gases such as  $\text{CH}_4$ ,  $\text{CO}_2$ ,  $\text{NH}_3$ ,  $\text{CH}_3\text{SH}$ ,  $\text{N}_2$ ... these emissions greatly affect the health of the surrounding people. Determining the minimum distance to place the waste collection site with housing is essential. This paper uses the Gaussian diffusion model to simulate and determine the concentration of emissions from the waste collection site by distance in specific climatic conditions for housing areas in Thai Nguyen province in Vietnam. Then determine a safe distance to arrange a place for waste collection site in the planning of residential areas in Thai Nguyen province in Vietnam.

**Index Terms**— Thai Nguyen; Housing areas; The waste collection site; Diffusion; Mecaptans;  $\text{NH}_3$ .

## I. INTRODUCTION

In Vietnam, the planning of waste collection site in housing areas has not been given adequate attention. The waste collection site emitting gases such as:  $\text{CH}_4$ ,  $\text{CO}_2$ ,  $\text{NH}_3$ ,  $\text{CH}_3\text{SH}$ ,  $\text{N}_2$ ... (Table1) causing unpleasant smell and greatly affecting human health [1]. Researching the distance of the waste collection site placement so that waste concentrations do not affect people living in residential areas is an important issue to ensure the health of residents living in housing areas. There have been many studies offering solutions to arrange the waste collection site in housing planning [2, 3]. Previous studies have just stopped at the planning of the waste collection site based on criteria of the accessibility of traffic, consistent with the transport route to the centralized landfill sites but not concerned with determining a safe distance to place the waste collection site. Determining a safe distance to place a the waste collection site that has little impact on the surrounding population is a complex issue because the concentration of gases generated from the waste collection site depends on the diffusion process and climate conditions. In this paper, the Gaussian diffusion model is proposed to calculate the concentration of the waste collection site to determine the safe distance between houses and the waste collection site in the planning of housing areas of Thai Nguyen province in Viet Nam.

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**Table 1.** Gases in the waste collection site [1]

Gases	% (Dry volume)
$\text{CH}_4$	45-60
$\text{CO}_2$	40-60
$\text{N}_2$	2-5
$\text{O}_2$	0.1 – 1.0
Mercaptans	0 – 1.0
$\text{NH}_3$	0.1 – 1.0
$\text{H}_2$	0 – 0.2
CO	0 – 0.2
Other gases	0.01 – 0.6

## II. METHODOLOGY AND RESEARCH SUBJECTS

This paper uses the Gaussian diffusion model [4, 5] to calculate the concentration of pollutant emissions declining by distance from the prevailing wind direction of winter and summer of Thai Nguyen province in Viet Nam. From that result, it is compared with [10] to determine the minimum distance of houses to the waste collection site.

### 2.1. Gaussian diffusion model

To calculate the decrease in gas concentration at the waste collection site, the coordinate system is calculated with the center located at the waste collection site, the Oz axis is set according to the height of the waste collection site, the OX axis is placed in the same direction with the wind blowing and the OY axis is set according to squared perpendicular to OX on the horizontal surface plane.

The equation describing the diffusion of emissions is as follows [4, 5, 6, 7]:

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial y} D_y \frac{\partial c}{\partial y} + \frac{\partial}{\partial z} D_z \frac{\partial c}{\partial z} - v \frac{\partial c}{\partial x} - \lambda c \quad (1)$$

General solution formula:

$$c(x, y, z) = \frac{Q}{4\pi x \sqrt{D_y D_z}} \exp\left(-\frac{vy^2}{4xD_y}\right) \left[ \frac{\exp\left(-\frac{v(z-H)^2}{4xD_z}\right)}{+\exp\left(-\frac{v(z+H)^2}{4xD_z}\right)} \right] \exp\left(\frac{\lambda}{v} x\right) \quad (2)$$

With the height of the waste source unchanged, we have:

$$C(x, y) = \frac{Q}{\pi v \sigma_y \sigma_z} \exp\left(-\frac{1}{2} \left( \frac{y^2}{\sigma_y^2} + \frac{H^2}{\sigma_z^2} \right)\right) \quad (3)$$

Where: C - gas concentration ( $\text{gm}^{-3}$ ); Q - emission rate ( $\text{gs}^{-1}$ ); v- wind speed ( $\text{ms}^{-1}$ );  $\sigma_y$ - diffusion coefficient for horizontal wind direction (m);  $\sigma_z$ - diffusion coefficient for vertical wind direction (m); H - Height of waste source (m);

2.2. Object and scope of the study

The study area is characterized by the plain topography of hills that rise up to the north (Figure 1), the cold winter climate

is strongly influenced by the southeast wind in the summer and the northeast wind and North in the winter. Houses of the study area are mostly 2-3-storey individual houses

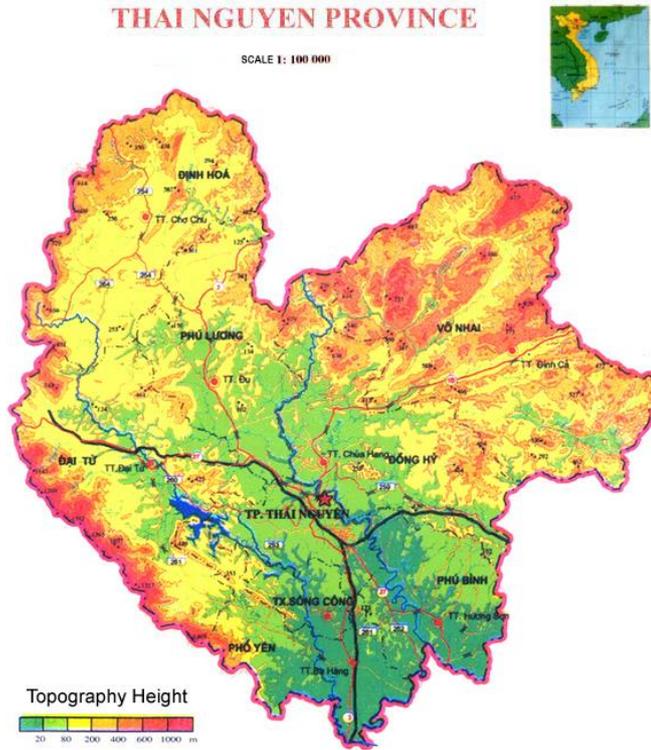


Figure 1. Topographic features of Thai Nguyen province in Vietnam [8]

According to the research results [1], the gases generated from the waste collection site have two gases that have the greatest impact on human health:  $\text{CH}_3\text{SH}$  (Mercaptans) and  $\text{NH}_3$ . Therefore, this study focuses on the calculation and simulation of diffusion of Mercaptans and  $\text{NH}_3$  (Table2).

Table 2. Emission rate, diffusion coefficients and permissible concentrations of Mercaptans and  $\text{NH}_3$  [9, 10]

Gas	Emission rate ( $\text{mgm}^{-2}\text{s}^{-1}$ )	Permissible concentrations ( $\text{mgm}^{-3}$ )
Mercaptans	58.93	0.05
$\text{NH}_3$	308.95	0.2

According to the current situation survey, the height of the waste collection sites varies from 1.5m to 3m, the area of the waste collection sites ranges from  $15\text{m}^2$  to  $30\text{m}^2$ . Therefore, in this study, height of waste source is  $H = 3\text{m}$ , area of calculation  $S = 30\text{m}^2$  was selected for simulation calculation.

III. RESEARCH RESULTS AND DISCUSSION

In Thai Nguyen, the Meteorological Center over 3 years of continuous statistics show that the winter with the highest wind frequency is the Northeast and the North, with the highest wind frequency in the summer is the Southeast. In winter, the largest wind speed is  $13.8\text{ms}^{-1}$  and the smallest wind speed is  $2.2\text{ms}^{-1}$  in the northeast, the largest wind speed is  $8.1\text{ms}^{-1}$  and the smallest wind speed is  $0.89\text{ms}^{-1}$  in the north. In the summer, the largest wind speed is  $7.2\text{ms}^{-1}$  and the smallest wind speed is  $1.8\text{ms}^{-1}$  in the southeast. The remaining directions have low wind frequency,

the largest wind speed is  $6.7\text{ms}^{-1}$  and the smallest is  $0.44\text{ms}^{-1}$  in all directions (Figure 2). Therefore, this study calculates a maximum wind speed of  $13.8\text{ms}^{-1}$  and a minimum wind speed of  $0.89\text{ms}^{-1}$  in winter and a maximum wind speed of  $7.1\text{ms}^{-1}$  and a minimum wind speed of  $1.8\text{ms}^{-1}$  in the summer. The remaining maximum wind speed is  $6.7\text{ms}^{-1}$  and the minimum wind speed is  $0.44\text{ms}^{-1}$  in the remaining seasons

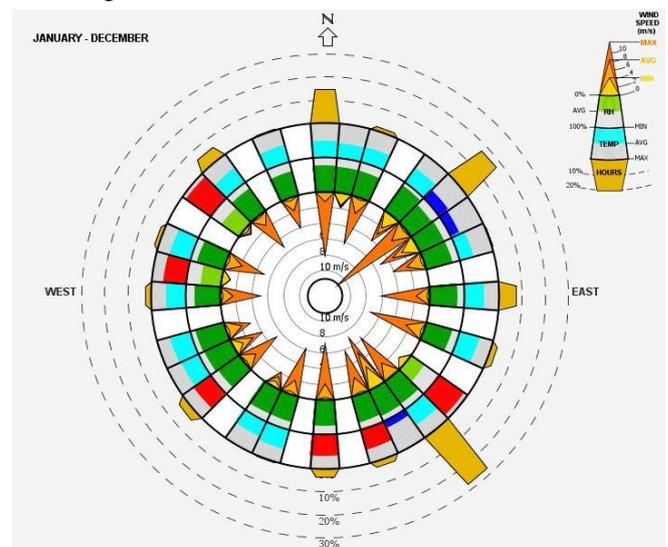


Figure 2. Wind speed and wind frequency in different directions in Thai Nguyen

Calculation results from the Gaussian diffusion model for Mercaptans and  $\text{NH}_3$  in different wind directions and

compared with the National Technical Regulation on Tables 3 and 4. Industrial Emission of Organic Substances are presented in

Table 3. Mercaptans concentration by distance according to wind directions

Season	Wind	Dis (m)	20	100	200	300	350	380	390	400	PC ( $mgm^{-3}$ )
		Winter	$Wind_{max}$	C ( $mgm^{-3}$ )	0.219	0.153	0.089	0.062	0.054	0.050	
	$Wind_{min}$	Dis (m)	20	100	200	300	400	410	420	430	
		C ( $mgm^{-3}$ )	0.948	0.202	0.103	0.069	0.052	0.050	0.049	0.048	
Summer	$Wind_{max}$	Dis (m)	20	100	200	300	350	400	410	420	
		C ( $mgm^{-3}$ )	0.464	0.178	0.096	0.066	0.057	0.050	0.049	0.048	
	$Wind_{min}$	Dis (m)	20	100	200	300	400	410	420	430	
		C ( $mgm^{-3}$ )	0.845	0.201	0.102	0.068	0.051	0.050	0.049	0.048	
Remaining seasons	$Wind_{max}$	Dis (m)	20	100	200	250	350	400	410	420	
		C ( $mgm^{-3}$ )	0.491	0.180	0.097	0.078	0.057	0.050	0.049	0.048	
	$Wind_{min}$	Dis (m)	20	100	200	300	400	410	420	430	
		C ( $mgm^{-3}$ )	0.997	0.207	0.104	0.069	0.052	0.051	0.049	0.048	

Table 4.  $NH_3$  concentration by distance according to wind directions ( $mgm^{-3}$ )

Season	Wind	Dis (m)	20	100	200	400	500	510	520	520	PC ( $mgm^{-3}$ )
		Winter	$Wind_{max}$	C ( $mgm^{-3}$ )	1.15	0.80	0.47	0.25	0.20	0.20	
	$Wind_{min}$	Dis (m)	20	100	200	400	500	540	550	560	
		C ( $mgm^{-3}$ )	4.94	1.07	0.54	0.27	0.21	0.20	0.19	0.19	
Summer	$Wind_{max}$	Dis (m)	20	100	200	400	500	530	540	550	
		C ( $mgm^{-3}$ )	2.43	0.93	0.50	0.26	0.21	0.20	0.19	0.19	
	$Wind_{min}$	Dis (m)	20	100	200	400	500	540	550	560	
		C ( $mgm^{-3}$ )	4.48	1.05	0.53	0.27	0.21	0.20	0.19	0.19	
Remaining seasons	$Wind_{max}$	Dis (m)	20	100	200	400	500	530	540	550	
		C ( $mgm^{-3}$ )	2.57	0.94	0.50	0.26	0.21	0.20	0.19	0.19	
	$Wind_{min}$	Dis (m)	20	100	200	400	500	540	550	560	
		C ( $mgm^{-3}$ )	5.22	1.08	0.54	0.27	0.21	0.20	0.19	0.19	

From the calculation results shown in table 3 and table 4, for Mercaptans we can see that the distance of waste source has a concentration greater than the permitted standard is 420m and for  $NH_3$  the distance of the waste source has a concentration greater than the permitted standard is 550m. Therefore, when planning of the waste collection site in the housing areas of Thai Nguyen province to ensure a safe distance for the health of the residents, it must arrange the waste collection site at least 550m away the housing.

#### IV. CONCLUSION

The waste collection site of Thai Nguyen province in Vietnam produces a lot of gases which greatly affect the health of residents in the housing area. Including Mercaptans and  $NH_3$  are the gases that have the largest impact on health of people. The paper uses the Gaussian dispersion model to determine the gas concentration of the waste collection site by distance in specific climatic conditions for housing areas of Thai Nguyen province in Viet Nam. The model shows that the safe distance of waste dumping ground to housing in rural mountainous residential areas in Thai Nguyen province is 550m in all seasons.

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