ASSESSMENT OF INDUSTRIAL AIR POLLUTION IN DA LAT CITY, VIET NAM, BY USING AIR DISPERSION MODELING

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ABSTRACT: Industry brings about pollution during its operation as well known. Specially, in the case that manufactories are scattered in residential area as occurring in Da Lat, a small city of Viet Nam (VN), the pollution becomes more harmful to human health. In order to clarify the air pollution level caused by industrial activities in the city, the project was designed to assess this air pollution by applying air dispersion modeling using BREEZE ISC model, an air pollution dispersion model developed by United States Environmental Protection Agency (US EPA). A survey was carry out to identify significant industrial sources. Then the simulation of air dispersion was done for five pollutants namely carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulate matter (PM). The main inputs for the model include source data, meteorological data, and terrain data. For source data, pollution emission loads were obtained by using two main methods, rapid assessment and stoichiometric calculation. Meteorological data were collected from local meteorological station, excepting mixing height which was calculated based on the method that recommended by New South Wales Environment Protection Authority (NSW EPA). A digital terrain elevation file was built and a Cartesian grid network was set up. The results give a full picture of pollution emission loads and ambient air pollution concentrations that cause by industrial sources which information is the first step toward air pollution management in the city.

INTRODUCTION

Together with many development processes in Viet Nam, industry is considering to contribute partial fraction of gross revenue. Beside the achieved economic benefit, industry has been causing many bad affects on environment including the air. Da Lat City, Viet Nam, where main industry sectors are food processing, green tea and coffee processing, stone quarrying, knitting… is in the same situation. The quality of air environment is affected much by the release of pollutants such as CO, sulfur oxide (SO_x), nitrogen oxide (NO_x), PM and etc. To assure sustainable development, air pollution control and management from industry activities are required.

Many solutions have been employed in air quality management by local government. But the use of air dispersion modeling is seemed to be new. In fact, air dispersion modeling is one of the most popular tools for the management since it can give useful information for decision makers. BREEZE ISC version 5.1 is such a model which uses Gaussian equation to estimate pollutant concentrations from a wide variety of sources associated with an industrial complex. This model can account for the following: settling and dry deposition of particles; downwash; point, area, line, and volume sources; plume rise as a function of downwind distance; separation of point sources; and limited terrain adjustment [1]. Till now, this model is widely applied and gives satisfactory results.

Therefore, the project was designed to assess air pollution from industry activities in the city by applying this model.

METHODOLOGY

Industrial source selection

A survey was carried out to inventory industrial air pollution sources accompany with their emission estimation in the studied area. The result shown that there are about 840 manufactories. Most of them do not release or just release small amount of polluted gases. Only 5 manufactories was assessed to be significant air pollution sources, namely Da Lat Beverage Company (C1), Lam Dong Food Company (C2), Da Lat Apex Company (C3), 757 Building Materials Company (C4), and Lam Dong Minerals and Building Materials Company (C5). The process that cause air pollution in C1, C2, and C3 is fuel combustion while it is stone quarrying in C4 and C5 as shown in Table 1.

Table 1 Significant Industrial Sources

Manu-factory	Process causing pollution	Capacity	Stack height, m	Stack diameter, m
C1	Anthracite coal combustion	70 kg fuel/h	14	0.4
C2	Kerosene combustion	37.6 kg fuel/h	4	0.3
C3	Diesel fuel combustion	29.7 kg fuel/h	17	0.5
C4	Stone transfer by conveyor belt	50 ton stone/h	-	-
C5	Stone transfer by conveyor belt	150 ton stone/h	-	-

Model input data estimation

In order to capture the highest pollution concentration in year, the simulation was designed to done on dry season and at the time when all manufactories operated with highest production capacity. After the survey, the selected modeling months were March and April 2008. Three types of input data were estimated to simulate the dispersion of polluted gase, they are source data, meteorological data, and terrain data.

Terrain data

A terrain file which is in digital elevation model (DEM) format was built (Fig.1.). A basemap of studied area was also prepared. A Cartesian receptor grid network was establish with 149 points in X (East - West) coordinate and 110 points in Y (North - South) coordinate. Distance between points was 200 m. Origin of the coordinates was selected at a longitude of 108°17′21″ East and a latitude of 11°48′17″ North. Source locations were determined by Global Positioning System (GPS) apparatus.

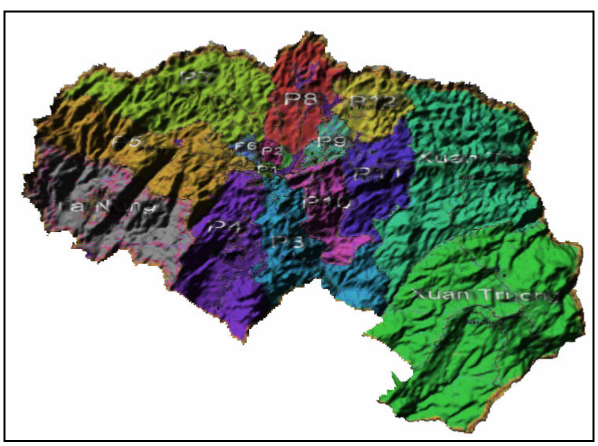

Figure 1 Terrain of Studied Area

Meteorological data

Meteorology condition plays an important role in air pollution dispersion. Parts of meteorological data including wind speed, wind direction, and ambient temperature were collected from local meteorological station. The others include stability class calculated using Pasquill method [3] as shown in Table 2 and mixing height, h, calculated using the equation 1 and 2 [2].

Table 2 Pasquill Stability Categories

Surface wind speed (at 10 m), m/s	Insolation			Night	
	Strong	Moderate	Slight	Thinly overcast or > 4/8 low cloud	3/8 cloud
<2	A	A – B	B	-	-
2 – 3	A – B	B	C	E	F
3 – 5	B	B – C	D	D	E
5 – 6	C	C – D	D	D	D
> 6	C	D	D	D	D

Source: Pasquill, 1961

$$h = 0.3u; \text{ for classes A – D} \quad (1)$$

$$h = 0.4(u^* L / f); \text{ for classes E and F} \quad (2)$$

where h is mixing height, m; u* is friction velocity, m/s; f is Coriolis parameter; L is Monin–Obukhov length, m.

Source data

Due to the difference of processes causing pollution of studied manufactories as described in section 2.1, two emission estimation methods were applied. Stoichiometric calculation was used to calculate the emission of polluted gases including CO, CO_2, SO_2, NO_2, and PM in combustion process. Rapid assessment was used to estimate PM emission in stone quarrying process.

In combustion process, base on the combustion reaction equations of fuels, the amount of oxygen required can be determined. Then the amount of air required as well as the amount of products (CO, CO_2, SO_2, and PM) can also be determined. The emission rates of NO_2 were calculated followed empirical equations 3 and 4 [4].

$$M_{NO2} = 3.953.10^{-8} Q; \text{ for solid fuel} \quad (3)$$

$$M_{NO2} = 1.723.10^{-3} B; \text{ for liquid fuel} \quad (4)$$

where M_{NO2} is emission rate of NO_2, kg/h; Q is heat released by fuel, kcal/h; B is mass of consumed fuel, kg/h.

In stone quarrying, many processes participate to cause particulate matter air pollution such as drilling, blasting, batch drop, conveying, crushing and etc. The survey results shown that the coarse stone conveying to crusher by conveyor belt cause most pollution. So the pollution from this process was selected to join in the air pollution modeling. The PM emissions from conveyor belt were estimated using rapid assessment as shown in following equation [5].

$$E = e; \tag{5}$$

where E is emission load, kg/year; Q is quantity of produced stone, ton stone/year; e is emission factor, kg/ton stone.

RESULTS AND DISSCUSSIONS

Industrial air pollution emission

The air pollution emission loads from all studied manufactories were shown in Table 3. The results shown that among three manufactories (C1, C2, and C3) that causing pollution by fuel combustion, C1 produced most pollution, compared to the others, due to the highest production capacity. Besides, coal that used by this manufactory produces higher emissions than oil that used by the others. All three manufactories had one or more pollutants which had concentrations exceeded emission standards. So exhaust gas treatment devices which have not yet installed in the manufactories are commented, specially in C1. In addition, operating and maintaining condition of combustion furnaces should take into account. It is also better for C1 to shift from coal to other cleaner fuel. C4 and C5 had the higher emission rate of PM which looks reasonable since these two manufactories work in stone quarrying. The PM emission rate of C5 is three times higher than that of C4 due to higher production capacity of this manufactory.

Table 3 Pollution Emission Rates, Q, and Concentrations, C, Produced by Studied Manufactories

Manufactory	Parameter	CO	CO_2	SO_2	NO_2	PM
C1	Q, g/s	1.29	38.62	0.31	0.04	4.59
	C, g/m³	3.46	103.19	0.83	0.11	12.28
	C, g/Nm³	6.74	201.47	1.62	0.21	23.97
C2	Q, g/s	1.04	31.15	0.01	0.04	0.01
	C, g/m³	2.74	81.94	0.03	0.09	0.02
	C, g/Nm³	5.35	159.98	0.05	0.18	0.05
C3	Q, g/s	0.83	24.84	0.08	0.03	0.01
	C, g/m³	2.66	79.27	0.26	0.08	0.01
	C, g/Nm³	5.18	154.77	0.51	0.16	0.03
C4	Q, g/s					2.36
C5	Q, g/s					7.08
Standard, g/Nm³		1	-	1.5	1	0.4

Base on the pollution emission load from each manufactory, the recommended efficiency of pollution treatments were as shown in Table 4.

Table 4 Required Treatment Efficiency of Air Pollutants

Pollutant	Treatment efficiency, %		
	C1	C2	C3
CO	85.2	81.3	80.7
SO_2	7.4		
PM	98.3		

Assessment of industrial air pollution

Using model inputs collected as described in section 2.2, model running was done to simulate the air dispersion of polluted gases released from studied manufactories. Outputs were selected to be highest 1 hour average concentrations. The results are shown in Fig. 2 - 6. From the results, it is indicated that the air pollutants were dispersed mainly from East to West which agreed with the prevailing wind direction during studied time.

For CO, CO_2, NO_2, SO_2, the most suffered area is Ward 11, nearly C1. This result looks reasonable since C1 had highest emission rate. The maximum concentrations of CO, CO_2, NO_2, SO_2 in the atmosphere were 1.51; 45.29; 0.05; 0.36 mg/m^3 respectively. Among these concentrations, only concentrations of SO_2 exceeded ambient standard.

For PM, the most suffered area is Ward 5, nearly C5. The highest concentration is 23.69 mg/m^3 which 79 times higher than that of ambient standard. So some measures need to be carried out to reduce the PM concentrations around the manufactory such as using covered equipments, spraying water on the ground to restrict particulate dispersion.

On the whole, fortunately, the 2 most suffered areas from industrial air pollution are not crowed residential ones. However, the damage to crop should take into consider in these areas.

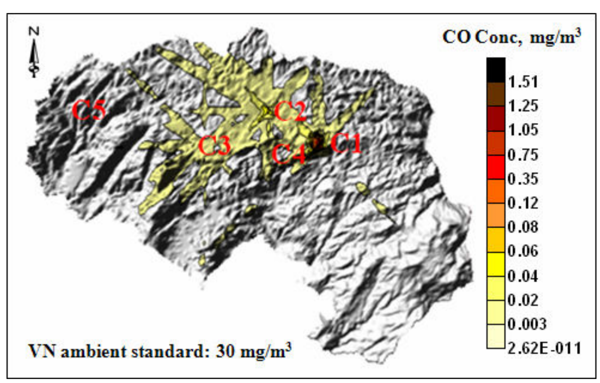

Figure 2 Highest 1 Hour Average CO Concentrations

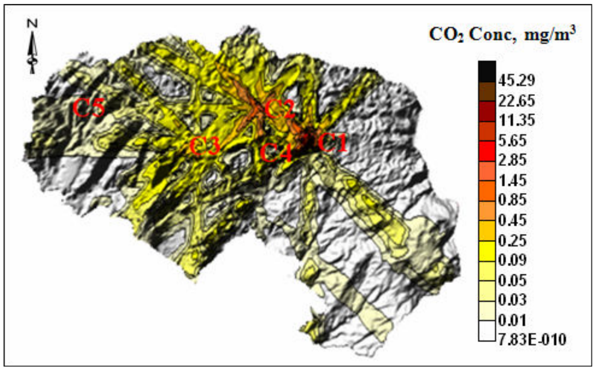

Figure 3 Highest 1 Hour Average CO_2 Concentrations

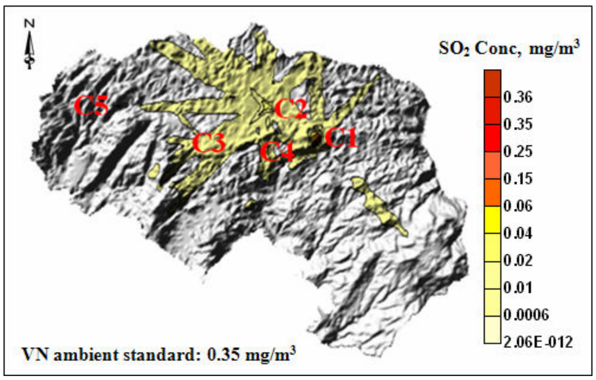

Figure 4 Highest 1 Hour Average SO_2 Concentrations

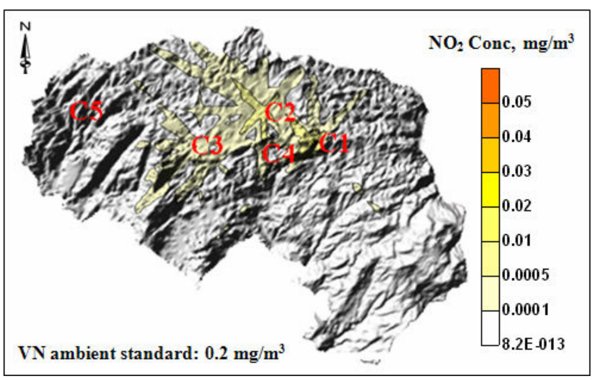

Figure 5 Highest 1 Hour Average NO_2 Concentrations

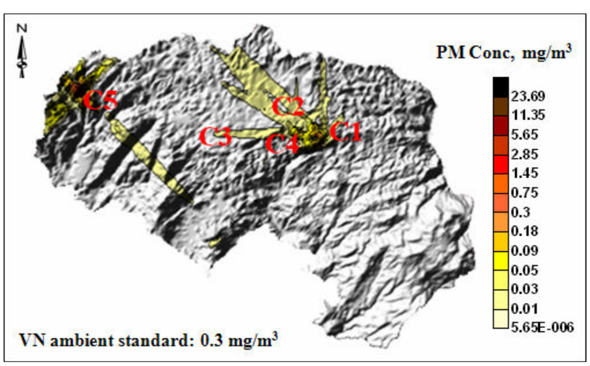

Figure 6 Highest 1 Hour Average PM Concentrations

CONCLUSIONS AND RECOMMENDATIONS

All studied manufactories use old production technologies. Combustion furnaces are handmade and not in good operating and maintaining conditions. Besides, environmental control has not paid much attention since no air pollution controlled equipments were installed. These resulted to high air pollution emission. All manufactories had pollution concentrations exceeded emission standard as revealed by project results. However, due to the low production capacity and small amount of manufactories in the city, the industrial air pollutant concentrations in the atmosphere were still acceptable. But in the next few years, the industrial activity will increase which will increase the air pollution. So to ensure sustainable development, air pollution management on source emission need to implement in advanced.

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