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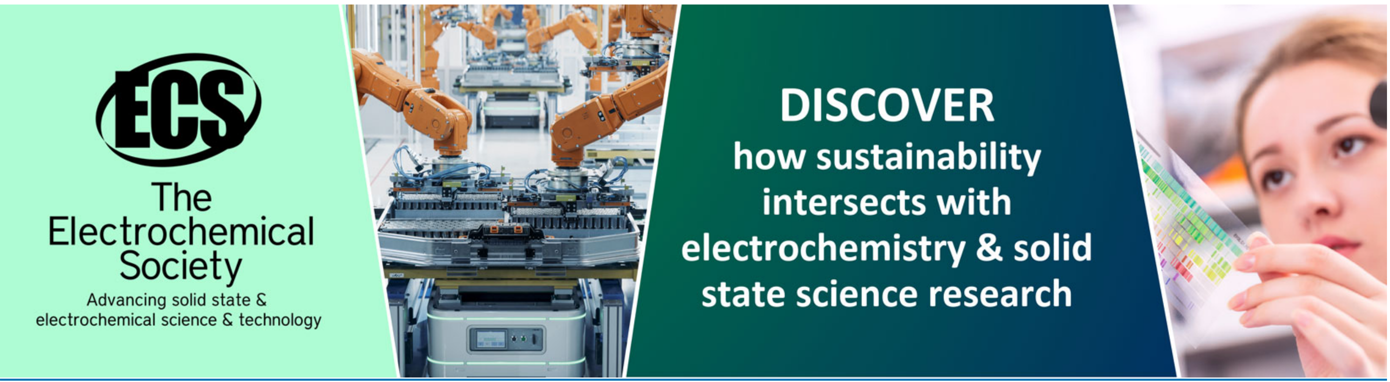

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Estimation of Urban Air Pollutant Levels using AERMOD: A Case Study in Nakhon Ratchasima, Thailand.

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Abstract. This research aims to study the possibility of using AERMOD air quality model to estimate the air pollutant levels of a selected city – Nakhon Ratchasima Municipality, Thailand. Four pollutants were studied: PM_{10}, CO, SO_2, and NO_x. The measurement data were obtained from a PCD automatic pollutant monitoring station for comparison with the model's results. The air pollution sources used were residential, furnace, traffic and industrial sources. Emission factors were used to estimate the concentration of pollutants from the activities of the population in the area. The estimation was based on the Top Down Approach method (TDA). Results shows that the pollutant concentrations obtained from the model were lower than the measurement values in all parameters. The values obtained from the model were 4.14% to 77.88% of the measurement values. The cause may be due to incomplete account of sources. However, the model can be useful for assessing the carrying capacity of the urban area.

1. Introduction

The city of Nakhon Ratchasima in north-eastern part of Thailand is a city of significant growth. The expansion of business and industrial sectors have been good for the economy but not so for the environment. One of the problem is air pollution, which is mostly due to human activities. Nakhon Ratchasima Municipality had only one automatic pollutant monitoring station owned and operated by the Pollution Control Departmentt (PCD). Based on recorded measurements, some air pollutants were exceeding standards. However, the fact that the measurement results are available from only one station in the city area making it difficult to gain the understanding of the overall level of pollutants. Since the AERMOD air quality model is popular for use in air quality monitoring, its ability could help solve this problem. Using the AERMOD air quality model [1] with estimated area and line sources representing the city's [2] emission can help predicting the air pollutant concentrate in the form of concentration isopleth. The model application can reduce the time and cost of the actual measurements while providing the visual interpretation of air pollution levels throughout the study area.

The objective of this research is to study the possibility of estimating air pollution concentrations in the city area using the AERMOD air quality model. The study area was selected to be Nakhon Ratchasima Municipality. Estimation of pollutants levels at the PCD monitoring station in the study area were compared with actual measurements. Four pollutants were studied: particulate matters smaller than *10* microns (PM_{10}), carbon monoxide (CO), sulphur dioxide (SO_2), and oxides of nitrogen (NO_x). The results can be used as an example of the application of AERMOD in air quality management of urban areas.

2. Materials and methods

2.1 Study Area and Pollutant Sources

The study area, Nakhon Ratchasima municipality, can be divided into residential areas based on the *4* constituencies as shown in Figure 1. The evaluation of air pollution was carried out using appropriate emission factors for 4 major air pollution sources: residential, furnace, traffic, and industrial sources.

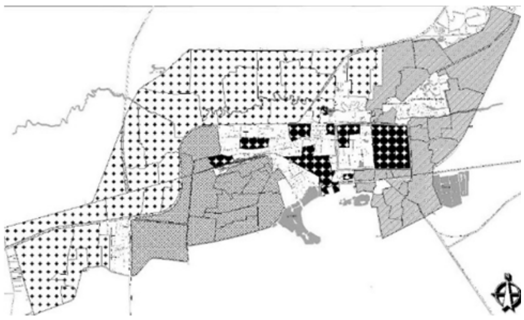

Figure 1. The district of Nakhon Ratchasima Municipality

2.2 Analysis Methods

2.2.1. Instrumentation The air pollutant measurement data used was secondary data obtained from PCD. The data came from an automatic air quality monitoring station of Nakhon Ratchasima Municipality. Its location is at 14.973785N, 102.085730E, which is approximately at the center of the city. This study used the measurement data in the year 2015 for the comparison with the pollution level estimated from the model. Four principle ambient air pollutants were studied, namely particulate matters smaller than 10 microns (PM_{10}), carbon monoxide (CO), sulphur dioxide (SO_2), and oxide of nitrogen (Nox).

2.2.2 Meteorological data This study uses the meteorological data of the year *2015* obtained from meteorological stations. The raw meteorological data was arranged into the required format of the AERMOD model: the hourly surface data was arranged into the SCRAM format, and upper air data was arranged into the FSL format. The data arrangement resulted in the forms of SFC File (*.SFC) and PFL File (*.PFL). The meteorological data was classified for every hour in the total period of one year for all parameters. The hourly surface data consisted of wind speed, wind direction, ambient temperature, cloud cover, and ceiling height. It was measured at Nakhon Ratchasima meteorological station, coordinate 14.973805, 102.085718. The upper air data consisted of atmospheric pressure, heights, temperature, dew point temperature, wind speed, and wind direction. It was measured at Bangkok Metropolis station, coordinate 13.726389, 100.559722.

2.2.3 AERMOD Modeling Option The air quality model used, AERMOD, consists of two sub-programs AERMET and AERMAP. They are programs that prepare meteorological information and geological terrain information, respectively, for the main program AERMOD. The two sub-programs act as pre-processor for data going into the main program. For this study, AERMAP used the terrain map type SRTM3/SRTM1 from WebGIS, the data was based on SRTM3 (Global 90m) and the horizontal datum was WGS 84. AERMET used the meteorological data from monitoring station measurement which was arranged into the SCRAM and FSL formats. The surface station primary tower (anemometer) was 186.6 m. In the AERMOD model, 4 pollution sources were entered: residential, furnace, traffic, and industrial sources. The receptors for the study area were defined by a uniform cartesian grid system, length 12,255.6 × 7,387 square meters. One discrete cartesian receptor was defined for the PCD automatic pollutant monitoring station, coordinate 14.973805,102.085718.

2.2.4 Emission Factors Determination Emission factors represent the relationship between pollutant emissions and pollution-related activities. In this study, the emission factors were based on the research on emission inventory in Nakhon Ratchasima Municipality, as shown in Table 1 [3]. The estimation of these emission factors was based on a "Top-Down Approach" (TDA). In order to update the emission values from the year 2012 to 2015, adjustments were made proportional to the change in the numbers of population. Overall, the emission in 2015 were less than in 2012 due to a decreasing trend in the city's population. The estimated emission data was entered into the AERMOD model in the unit of $g.s^{-1}.m^{-2}$ for area and line sources for further computation of the model.

Table 1. Emission factors of air pollution sources in Nakhon Ratchasima Municipality

Source	activities	Emission Factor (kilograms / unit of fuel)			
		NO_X	SO_2	CO	PM_{10}
Area	LPG (Liter)	0.001810	0.000010	0.001230	0.000100
	Fuel Wood (Kilograms)	0.000120	0.000320	0.026400	0.011110
	Charcoal (Kilograms)	0.000030	0.000180	0.035700	0.015690
Temple	Crematory (Kilograms)	0.115700	0.070850	0.096200	-
Industrial	Fuel Oil (1000 Liter)	8.000000	19.000000	0.600000	1.000000
	Diesel (1000 Liter)	2.400000	17.000000	0.600000	0.240000
	Diesel (1000 Liter)	2.400000	17.000000	0.600000	0.240000
	Kerosene (1000 Liter)	2.400000	17.000000	0.600000	0.240000
	LPG (1000 Liter)	2.280000	0.012000	0.384000	0.072000
	Fuel Wood (1000 Kilograms)	0.190000	0.037500	3.300000	23.500000
Traffic	Motorcycle (Kilometers.Car)	0.000240	0.000020	0.013140	0.000086
	Gasoline Engine Car (Kilometers.Car)	0.000026	0.000061	0.000513	0.000101
	Small Diesel Engine Car (Kilometers.Car)	0.000469	0.000041	0.000439	0.000042
	Big Diesel Engine Cars (Kilometers.Car)	0.023120	0.000327	0.008890	0.001150

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3. Results and discussion

3.1 Pollution levels estimated by AERMOD

The estimated annual average pollutant concentrations using the AERMOD air quality model are shown in Figure 2-5. The concentrations of NO_x, SO_2, CO and PM_{10} were found to be higher in the road network. The highest NO_x, SO_2, CO and PM_{10} concentrations in microgram/m^3 were 344.24, 12.53, 414.43 and 30.46, respectively. The maximum concentration of all pollutants was at the same point at coordinate 184246.47, 1657665.85. At the point of the discrete cartesian receptor, which is the location of the PCD air quality measurement station, the levels was found to be 13.78, 27.72, 0.60 and 4.63, respectively. From Figure 2-5, the dispersion of PM_{10} concentrations is the most apparent. The distribution of SO_2 concentrations is minimal. From Figure 3, it can be seen that SO_2 is highly concentrated near the pollution source.

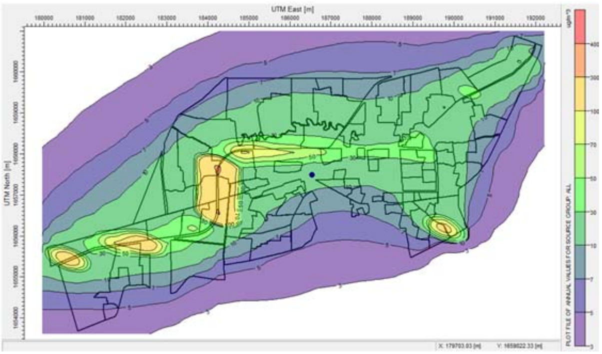

Figure 2. Oxide of nitrogen (NO_x) concentration estimates by AERMOD, annual averaging.

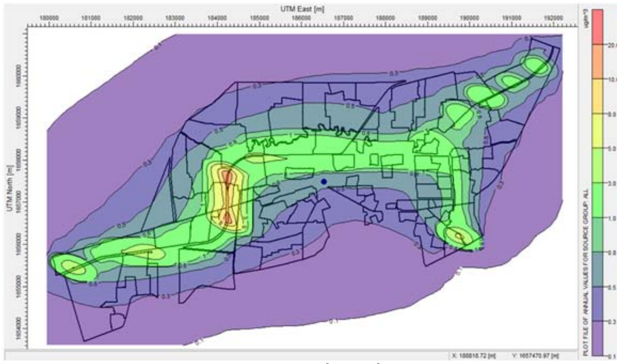

Figure 3. Sulphur dioxide (SO_2) concentration estimates by AERMOD, annual averaging.

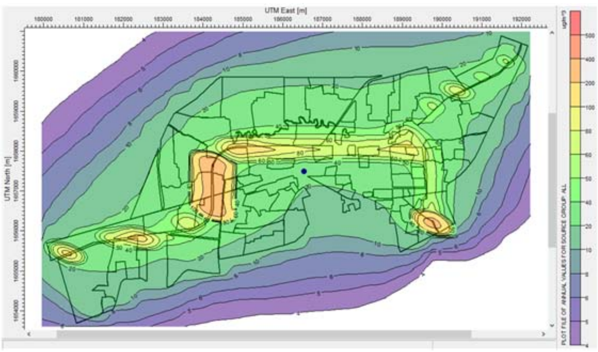

Figure 4. Carbon monoxide (CO) concentration estimates by AERMOD, annual averaging.

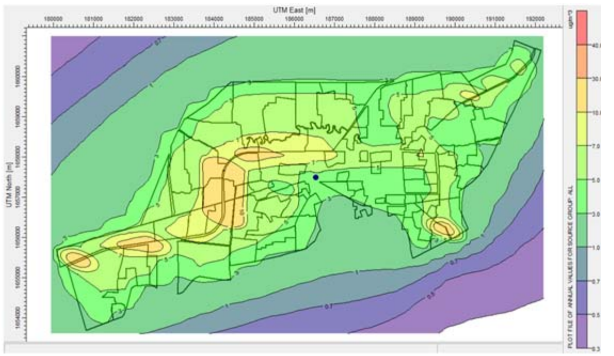

Figure 5. Particulate matter <10 microns (PM_{10}) concentration estimates by AERMOD, annual averaging.

3.2 Comparison between AERMOD results and measurement data

The estimation of annual pollution levels using the air quality model AERMOD were compared to the pollutant concentration measurement at the same location, as shown in Table 2. It was found that the pollutant concentrations derived from the model were lower than the measurement values in all pollutants. The values of NO_x, SO_2, PM_{10} and CO from AERMOD were 77.88%, 10.59%, 8.98% and 4.14% of those measured at the station, respectively. The reason that the model's estimation was lower than the actual measurement may be due to pollutant sources which are unaccounted for, such as dust resuspension from traffic and ground surfaces and other non-point sources.

Table 2. Comparison of measured pollutant concentration with AERMOD results.

Pollutants	Ambient Standard (ug/m^3)	Measurement (ug/m^3)	AERMOD (ug/m^3)
NO_x	57	17.69	13.78
CO	-	669.94	27.72
SO_2	100	5.68	0.60
PM_{10}	50	51.58	4.63

4. Conclusions

In this study, we investigated the possibility of using AERMOD to assist in predicting air pollution concentration in a city. Comparison of results with actual measurement at the same coordinate showed that the pollutant concentrations obtained from the model were lower in all parameters. The cause may be due to incomplete sources of pollutant incorporated in the analysis. Overall, the most concentrated area along the boundary road [4]. However, the results showed promising ability for the AERMOD model to be used as a tool for air quality management of a city, possibly for assessing the carrying capacity of the urban area.

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Acknowledgments

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