ตัวแบบการวิเคราะห์ปริมาณฝุ่นในกรุงเทพมหานครด้วยทฤษฎีเกรย์
Model Analysis of Air Pollution in Bangkok by Grey's Theory

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บทคัดย่อ

ในการศึกษา ตัวแบบเกรย์ (Grey's Model (GM)) เพื่อพยากรณ์ปริมาณฝุ่นละอองขนาดเล็กกว่า 10 ไมครอน ค่าเฉลี่ย 24 ชั่วโมง (SPM10) ในกรุงเทพมหานครซึ่งเป็นจังหวัดท่องเที่ยวของประเทศไทย โดยตั้งแต่ พ.ศ. 2551-2558 รวม 8 ปีและค่าฝุ่นละออง SPM10 รอบ 5, 10, และ 20 ปี ข้างหน้าซึ่งตรงกับ พ.ศ. 2570, 2575 และ 2580 ตามลำดับ พบว่าค่าปริมาณฝุ่นละออง SPM10 พยากรณ์จะมีแนวโน้ม 2 แบบ คือ 1. สถานีที่มีแนวโน้มเพิ่มขึ้น ได้แก่ ไปรษณีย์ราษฎร์บูรณะ กรมอุตุนิยมวิทยาบางนา สำนักงานการเคหะชุมชนคลองจั่น สนามกีฬาการเคหะชุมชนห้วยขวาง โรงเรียนนนทรีวิทยา โรงพยาบาลจุฬาลงกรณ์ และโรงเรียนบดินทรเดชา (สิงห์ สิงหเสนี) 2. สถานีที่มีแนวโน้มลดลง ได้แก่ มหาวิทยาลัยราชภัฏบ้านสมเด็จเจ้าพระยา กระทรวงวิทยาศาสตร์และเทคโนโลยี กรมขนส่งทางบก สถานีการไฟฟ้าย่อยธนบุรี ตำรวจนครบาลโชคชัย และตรวจวัดการเคหะชุมชนดินแดง ทั้งนี้จากค่าพยากรณ์ปริมาณฝุ่นละออง SPM10 ในอนาคตแสดงถึงการบริหารการจัดการที่ดี ลดปริมาณฝุ่นละออง ก็จะสามารถพัฒนาสนับสนุนการท่องเที่ยวแบบยั่งยืน เสริมสร้างภาพลักษณ์ที่ดีของประเทศได้

คำสำคัญ: ทฤษฎีเกรย์, ปริมาณฝุ่นละอองขนาดเล็ก, ธรรมชาติของจังหวัดท่องเที่ยว, การพยากรณ์

สาขาวิชาคณิตศาสตร์ คณะวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยเทคโนโลยีราชมงคลสุวรรณภูมิ วิทยาเขตสุพรรณบุรี ตำบลย่านยาว อำเภอสามชุก จังหวัดสุพรรณบุรี 72130
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ABSTRACT

In this study, Grey's Model (GM) was used to forecast the amount of suspended particulate matter, which is smaller than 10 microns (SPM10) with 24 hour mean in Bangkok, which is a famous tourist destination in Thailand. The predictive value of a small amount of suspended particulate matter in tourism during an 8-year period (2551-2558 B.E.) and in the next 5, 10, and 20 years (2570, 2575, 2580 B.E.) showed the two results as follows: Firstly, there was increasing suspended particulate matter in some stations such as Ratchaburana Post Office Station, Department of Meteorological (Bangna Station), Housing Authority Office of Clong Chan Community Station, Stadium of Huai Kwang Housing Authority Station, Nonsiwitthaya School Station, Chulalongkorn Hospital Station, and Bodindecha School Station Sing Singhaseni. Secondly, there was decreasing suspended particulate matter in some stations such as Bansomdejchaopraya Rajabhat University Station, Ministry of Science and Technology Station, Department of Land Transport Station, MEA Substation Thonburi Station, Chokchai Metro Police Office Station, and Housing Authority Office of Din Daeng Community Station. The amount of suspended particulate matter forecast which is smaller than 10 microns (SPM10) showed that if there are good control and management of suspended particulate matter, the amount of suspended particulate matter will be decreased and it will be good for supporting sustainable tourism and strengthening the image of the country.

Key words: grey theory, suspended particulate matter, natural of travel's province, forecasting

INTRODUCTION

Tourism is one of the main incomes of Thailand. There are high competitions in tourism in Southeast Asia. However, Thailand has more advantages than other Southeast Asian countries as its culture is outstanding and unique. Also, there are various types of tourism in Thailand such as architectures, caves, waterfalls, local culture, language, minorities, folk plays, and natures. All of them are so important that the government should support both major cities and minor cities in Thailand to be attractive and impressive in order to bring a lot of tourists to spend time and money there. Bangkok, the capital city of Thailand, is still popular among tourists as it can be seen that a number of tourists entering Thailand during 2549-2554 B.E. were 36,172,138, 35,953,546, 35,110,693, 30,037,911, 38,222,903 and 43,763,002, tourists, respectively. The number of tourists in Bangkok tends to continuously increase every year and higher than those in other provinces. Additionally, the amount of increasing population causes many environment problems such as air pollution, noise pollution, and garbage. Also, there is an increase of criminals. Air pollution is one of the big problems of the capital city. It comes from vehicles and industrial factories such as carbon dioxide gas, hydrocarbon, nitrogen oxide, suspended particulate matter, lead, and sulfur dioxide. The air pollution causes bad quality of air and health. In this study, the classified air pollution from the examination into two types. The first type is "Total Suspended Particulate: TSP", which causes irritations of respiratory and bad visuals. The second type is "Suspended Particulate Matter: SPM10", which is the particulate that is smaller than ten microns, can get into the respiratory system of human being, and is dangerous to sinus, oral cavity, larynx, trachea, and bronchus. It causes irritation, cough, sneeze and illness as well as economics and social lost. The chemical substance from industrial factories was released into the air and the amount is above the level of air quality control. In

Bangkok, the suspended particulate matter is smaller than 10 microns (SPM10) and there is suspended particulate matter that is smaller than 2.5 microns (SPM2.5), which is above the controlling standard level and dangerous to health. If the air pollution is under control, it can be used as basic information which is useful for preventing and solving air pollution problems.

Grey theory is a model finding trend of forecast value from many sources of data, such as medicine, agriculture, engineering, economics, and marketing. All the data were made in grey model (GM) by Deng (1989). Moreover, there were further studies developed, such as those from Yang and Wen (1997), Diyar and Mehmet (2007), Dend (2005), Erdal *et al*. (2010). The analysis of the GM is suitable for data with uncertain formats but GM is popular to use in accurate forecasts. The GM considers the value of beginning data to find parameter estimation and there must not be so many data to be analyzed. Therefore, the study of GM is suitable with the SPM10 data from 14 stations in Bangkok, and can be used to forecast the amount of suspended particulate matter in the future onward.

MATERIALS AND METHODS

In the research, the GM was used to analyze the amount of SPM10 in Bangkok from 14 weather radar stations, such as Bansomdejchaopraya Rajabhat University Station (02T), Ratchaburana Post Office Station (03T original), Department of Meteorological (Bangna station) (05T), Housing Authority Office of Clong Chan Community Station (10T), Stadium of Huai Kwang Housing Authority Station (11T), Nonsiwitthaya School Station (12T), Ministry of Science and Technology Station (48R), Department of Land Transport Station (49), Chulalongkorn Hospital Station (50R), MEA Substation Thonburi station (52R), Chokchai Metro Police Office Station (53R), Housing Authority Office of Din Daeng Community Station (54R), The Government Public Relations Department Station (59T) and Bodindecha School Station (Sing Singhaseni) (61T), from year 2551-2558 B.E. totally eight years. Then the accuracy of the GM was compared with mean absolute percentage error: MAPE

The GM is beginning data as equation (1) below,

$$x^{(0)} = \left\{x^{(0)}(1), x^{(0)}(2),..., x^{(0)}(m)\right\} \quad (1)$$

Then find sum total value of primary data as the equation (2)

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), k = 1,2,...,m\,. \quad (2)$$

And from sum total value of data is $x^{(1)} = \left\{, x^{(1)}(1), x^{(1)}(2),..., x^{(1)}(m)\right\}$. It can find mid-range and derivation of sequence of data in GM is $\frac{dx^{(1)}}{dt} + ax^{(1)} = b$. Therefore, to find derivation of function will be as below,

$$x^{(0)}(k) + az^{(1)}(k) = b\,. \quad (3)$$

When a and b is parameter of the model and k is sequence of data as the equation (3)

To estimate the parameter by least sequence will be as below

$$[a,b]^T = \left(B^T B\right)^{-1} B^T Y_m . \quad (4)$$

When $Y_m = \left[x^{(0)}(2), x^{(0)}(3),..., x^{(0)}(m)\right]$ and $B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(m) & 1 \end{bmatrix}$ then calculate the new value as following

$$z^{(1)}(k+1) = \frac{1}{2}\left(x^{(1)}(k) + x^{(1)}(k+1)\right), k = 1,2,..., m-1. \quad (5)$$

To find forecast value of the GM is $\hat{x}^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a}\right)e^{-ak} + \frac{b}{a}$, it can be written as below

$$\hat{x}^{(0)}(k+1) = x^{(1)}(k+1) - x^{(2)}(k) = \left(1 - e^{a}\right)\left(x^{(0)}(1) - \frac{b}{a}\right)e^{-ak}, k = 1,2,..., k-1.$$

In the sequence of data $z^{(1)}(k+1)$ to find the original function for $x^{(1)}$, and

$$z^{(1)}(k+1) = \frac{1}{2}\left(x^{(1)}(k) + x^{(1)}(k+1)\right). \quad (6)$$

To find $x^{(1)}(k)$ is to replace by exponential function. Mathematical estimation is an alternative to find estimation and decrease mean absolute percentage errors as the equation (7), that showed the most proper beginning value

$$z^{(1)}(k+1) = \frac{23}{54}x^{(1)}(k) + \frac{35}{54}x^{(1)}(k+1) - \frac{2}{27}x^{(1)}(k+2) \quad (7)$$

Estimation of properness is to consider the properness of forecast value of amount of the SPM10 in Bangkok by errors as below

$$\varepsilon^{(0)} = \{\varepsilon(1), \varepsilon(2),..., \varepsilon(m)\} \quad (8)$$
$$= \left\{x^{(0)}(1) - \hat{x}^{(0)}(1), x^{(0)}(2) - \hat{x}^{(0)}(2),..., x^{(0)}(m) - \hat{x}^{(0)}(m)\right\}.$$

Then find mean absolute percentage errors: MAPE as below.

$$MAPE = \left(\frac{1}{m}\sum_{i=1}^{m}\left|\frac{\hat{x}(i) - x(i)}{x(i)}\right|\right) \text{ , for } i = 1,2,..., m .$$

RESULTS AND DISCUSSION

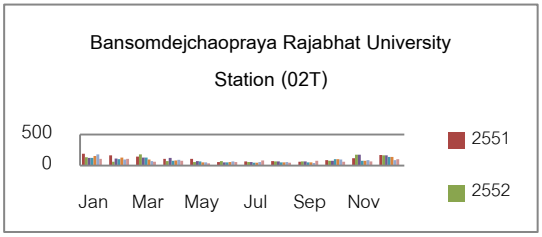
1. Data of the amount of the SPM10 in Bangkok: Bangkok is the capital city of Thailand and has the most population. Also, it is the center of education, transportation, bank and financial, communication, and center of all development. Bangkok has Chao Phraya River flowing through and has many important tourist destinations such as the Grand Palace, Wat Phra Si Rattana Satsadaram, Wat Arun Ratchawararam, Wat Benchamaborphit Dusitwanaram, the Ananta Samakhom Throne Hall, Siam Square, Madame Tussauds Bangkok, Asiatique, shopping malls, and many more tourist sites in Bangkok. The important tourist spots and the data of the SPM10 collected in Bangkok were the amount of the SPM10 in each station that tended to increase and had air quality problems in 8 years during the years 2551-2558 B.E. The 14 weather radar stations in Bangkok are shown in Table 1 and Figure 1.

Table 1 Amount of the SPM10 of 14 stations in Bangkok

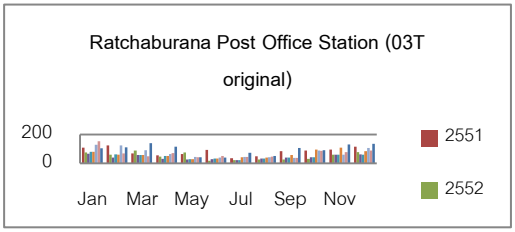
Weather radar stations	**Basis information and general information**
1. Bansomdejchaopraya Rajabhat University	Amount of the SPM10 was high in January, February, March, November and December.
2. Ratchaburana Post Office (Original)	Amount of the SPM10 was high in January, February, March, October, November and December. Moreover, it was found that the amount of the SPM10 during years 2556-2558 B.E. was very high.
3. Department of Meteorological (Bangna)	Amount of the SPM10 was high in January, February and December. Moreover, it was found that the amount of the SPM10 during January of years 2556-2557 B.E. and in February of year 2551 B.E. and in February of year 2555 B.E. was very high.
4. Housing Authority Office of Clong Chan Community	Amount of the SPM10 was high in January, February, March, November and December. Moreover, it was found that the amount of the SPM10 during January to March of years 2551-2553 B.E. and November to December of years 2552-2554 B.E. was very high.
5. Stadium of Huai Kwang Housing Authority	Amount of the SPM10 was high in January, February, March, November and December. Moreover, it was found that the amount of the SPM10 during January to March of year 2551 B.E. and in June of years 2554-2556 B.E. was very high.
6. Nonsiwitthaya School	Amount of the SPM10 was high in January, February, March, November and December. Moreover, it was found that the amount of the SPM10 during January to March of year 2551 B.E. and in June of years 2554-2556 B.E. was very high.
7. Ministry of Science and Technology	Amount of the SPM10 was high in January, February, March, November and December. Moreover, it was found that the amount of the SPM10 during January to March of years 2555-2557 B.E. and November to December of years 2552-2556 B.E. was very high.
8. Department of Land Transport	Amount of the SPM10 was high in January, February, March, November and December. Moreover, it was found that the amount of the SPM10 during January to March of years 2551-2553 B.E. and November to December of years 2552-2554 B.E. was very high.
9. Chulalongkorn Hospital	Amount of the SPM10 was high in January, February, March, November and December. Moreover, it was found that the amount of the SPM10 during January to March of years 2555-2556 B.E. and in December of years 2552-2556 B.E. was very high.
10. MEA Substation Thonburi	Amount of the SPM10 was high in January, February, March, November and December. Moreover, it was found that the amount of the SPM10 during January to March, and in December of year 2551 B.E. and in November of year 2556 B.E. was very high.
11. Chokchai Metro Police Office	Amount of the SPM10 was high in January, February, March, November and December. Moreover, it was found that the amount of the SPM10 during January to March of year 2551 B.E. and in June of years 2554-2556 B.E. was very high.

Table 1 (Continued)

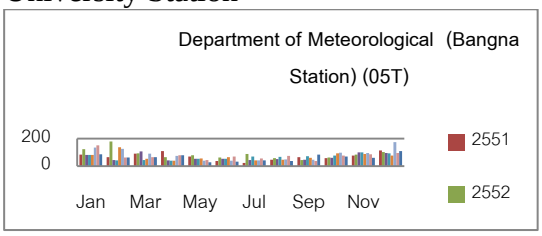
Weather radar stations	Basis information and general information
12. Housing Authority Office of Din Daeng Community	Amount of the SPM10 was high in January, February, March, November and December. Moreover, it was found that the amount of the SPM10 during January to March and October to December of years 2551-2553 B.E.
13. The Government Public Relations Department	Amount of the SPM10 was high in January, February, and March. Moreover, it was found that the amount of the SPM10 in January to February of years 2556-2558 B.E. and in March of years 2551-2553 B.E. was very high.
14. Bodindecha School (Sing Singhaseni)	Amount of the SPM10 was high in January, February, and December. Moreover, it was found that the amount of the SPM10 in January of years 2556-2558 B.E. in February of year 2551 B.E. and in December of years 2556-2558 B.E. was very high.



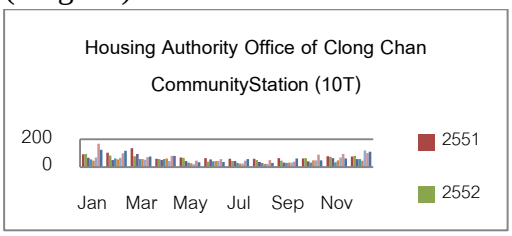
(1) Bansomdejchaopraya Rajabhat University Station



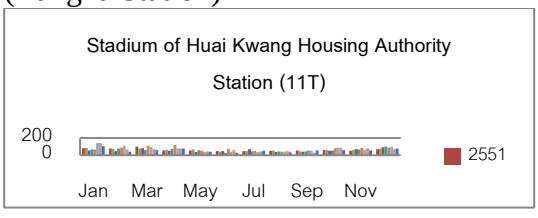
(2) Ratchaburana Post Office Station (Original)



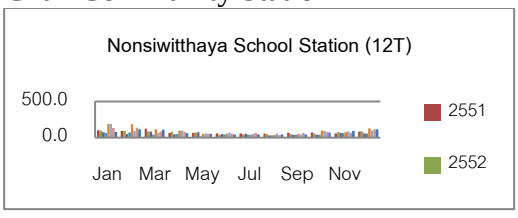
(3) Department of Meteorological (Bangna Station)



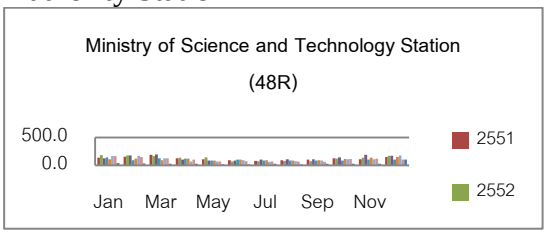
(4) Housing Authority Office of Clong Chan Community Station



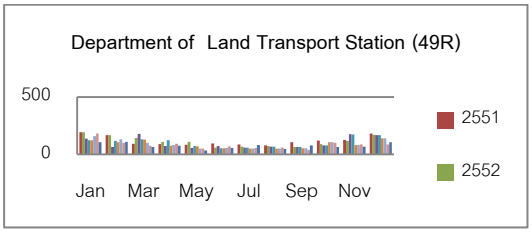
(5) Stadium of Huai Kwang Housing Authority Station



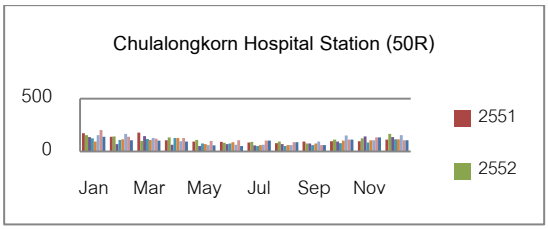
(6) Nonsiwitthaya School Station



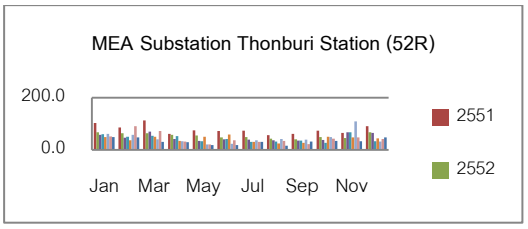
(7) Ministry of Science and Technology Station



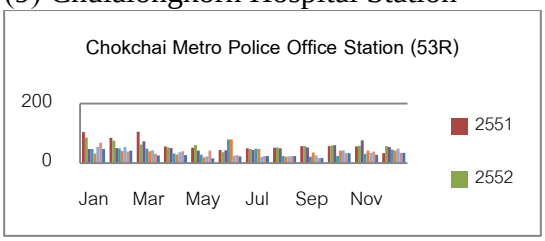
(8) Department of Land Transport Station



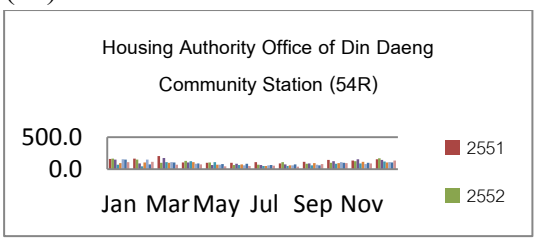
(9) Chulalongkorn Hospital Station



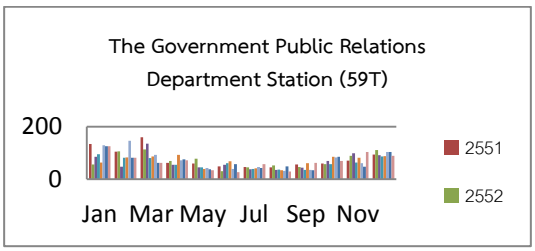
(10) MEA Substation Thonburi Station



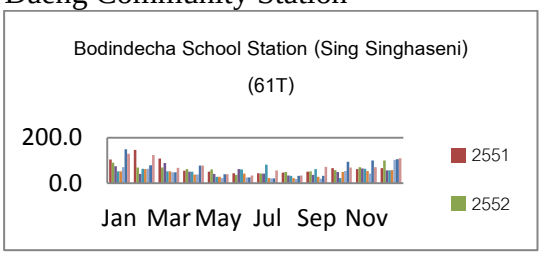
(11) Chokchai Metro Police Office Station



(12) Housing Authority Office of Din Daeng Community Station



(13) The Government Public Relations Department Station



(14) Bodindecha School Station (Sing Singhaseni)

Note Air quality index.

0-25 mcg/m^3 Very good	26-37 mcg/m^3 good	38-50 mcg/m^3 moderate	51-90 mcg/m^3 Start to have an impact health	>90 mcg/m^3 Have an effect health

Figure 1 Amount of the SPM10 from 14 weather radar stations

2. Model of amount of suspended particulate matter in Bangkok: The GM was used to find parameter and mean absolute percentage error: MAPE in the model of amount of the SPM10 in Bangkok by forecast value showing trending value of the SPM10 in the future in 5, 10, and 20 years, which are 2565, 2570 and 2580 B.E. as the following.

2.1 Data of parameter and mean absolute percentage error: MAPE of use of GM in each station are displayed in Table 2.

Table 2 Parameters and MAPE of use of GM to find the SPM10 in Bangkok

Weather radar stations	**Parameters**		**Errors**	
	a	**b**	**MAPE**	**Relation error (RE)**
1. Bansomdejchaopraya Rajabhat University	0.0563	121.4482	14.0076	17.4197
2. Ratchaburana Post Office (Original)	-0.1250	29.5249	24.7768	51.8218
3. Department of Meteorological (Bangna)	0.0222	78.6674	23.2480	39.5555
4. Housing Authority Office of Clong Chan Community	-0.0377	45.8700	24.4011	50.3005

Table 2 (Continued)

Weather radar stations	Parameters		Errors	
	a	b	MAPE	Relation error (RE)
5. Stadium of Huai Kwang Housing Authority	-0.0020	62.4334	18.3453	54.8669
6. Nonsiwitthaya School	-0.0424	56.1027	25.2768	57.4015
7. Ministry of Science and Technology	0.1091	161.9240	34.7498	80.4171
8. Department of Land Transport	0.0563	121.4480	15.1024	18.0336
9. Chulalongkorn Hospital	-0.0033	100.93290	16.7806	19.0219
10. MEA Substation Thonburi	0.0650	58.7330	17.7784	46.4297
11. Chokchai Metro Police Office	0.1266	68.5425	20.9162	58.1631
12. Housing Authority Office of Din Daeng Community	0.0497	120.2770	15.8988	18.8925
13. The Government Public Relations Department	0.0051	69.8138	17.1696	31.4525
14. Bodindecha School (Sing Singhaseni)	-0.0173	47.7702	27.7297	64.6542

Table 2 shows that parameter "a" has opposite value such as Ratchaburana Post Office Station (Original), Housing Authority Office of Clong Chan Community Station, Stadium of Huai Kwang Housing Authority Station, Nonsiwitthaya School Station, Chulalongkorn Hospital Station and Bodindecha School Station (Sing Singhaseni). The parameter "b" presented the same direction value in every station. The MAPE showed the opposite result such as Bansomdejchaopraya Rajabhat University Station, Ministry of Science and Technology Station, Department of Land Transport Station, MEA Substation Thonburi Station, Chokchai Metro Police Office Station, Housing Authority Office of Din Daeng Community Station and found that the error relation value was in the same direction in every station. However, if the error value is considered from least to most, it will be stated with Ministry of Science and Technology Station, Bansomdejchaopraya Rajabhat University Station, Department of Land Transport Station, Chulalongkorn Hospital Station, Housing Authority Office of Din Daeng Community Station, Stadium of Huai Kwang Housing Authority Station, the Government Public Relations Department Station, MEA Substation Thonburi Station, Department of Meteorological (Bangna Station), Housing Authority Office of Clong Chan Community Station, Chokchai Metro Police Office Station, Ratchaburana Post Office Station (Original) and Nonsiwitthaya School Station.

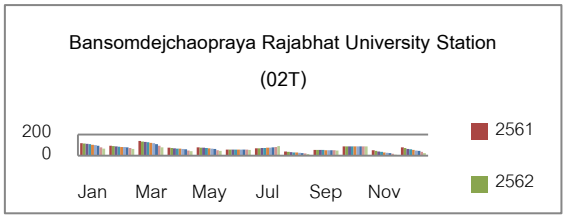
2.2 The GM indicated trending value of amount of the SPM10 in the future in 5, 10 and 20 years, which are 2565, 2570 and 2580 B.E. as reported in Table 3 and Figure 2 below.

Table 3 Forecast model of amount of the SPM10 in the future in 14 stations

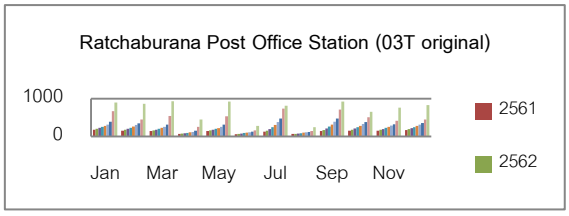
Weather radar stations	Forecast data of amount of the SPM10 in the future
1. Bansomdejchaopraya Rajabhat University	Amount of the SPM10 tends to decrease in years 2561-2566 B.E. except in June, and in September, it is constant. However, it tends to increase in July of year 2580 B.E.
2. Ratchaburana Post Office (Original)	Amount of the SPM10 tends to increase in years 2561-2566, 2570, 2575 and 2580 B.E.
3. Department of Meteorological (Bangna station)	Amount of the SPM10 tends to increase in years 2561-2566 B.E. and will be increasing more in years 2570, 2575 and 2580 B.E. However, it tends to decrease in February, April, June to August, and November.
4. Housing Authority Office of Clong Chan Community	Amount of the SPM10 tends to increase during January to May of years 2561-2566 B.E. and will be decreasing in June to August, and in November of years 2570, 2575 and 2580 B.E.
5. Stadium of Huai Kwang Housing Authority	Amount of the SPM10 is high in January, March to May, and will be increasing a lot in February, June and December of years 2570, 2575 and 2580 B.E.
6. Nonsiwitthaya School	Amount of the SPM10 is increasing from January to May of years 2561-2566 B.E. and will be increasing considerably in years 2570, 2575 and 2580 B.E. The constant trending is in February, and June to September
7. Ministry of Science and Technology	Amount of the SPM10 is decreasing from January to December of years 2561-2566 B.E. and will be decreasing substantially in years 2570, 2575 and 2580 B.E.
8. Department of Land Transport	Amount of the SPM10 is decreasing from January to May and November to December of years 2561-2566 B.E. and will be decreasing much in years 2570, 2575 and 2580 B.E. The constant trending is in June and September to October.
9. Chulalongkorn Hospital	Amount of the SPM10 is increasing from January to May, July and October to November of years 2561-2566 B.E. and will be increasing a lot in years 2570, 2575 and 2580 B.E. The constant trending is in June, August to September and December.
10. MEA Substation Thonburi	Amount of the SPM10 is decreasing from January to December of years 2561-2566 B.E. and will be decreasing significantly in years 2570, 2575 and 2580 B.E. It tends to increase in February.
11. Chokchai Metro Police Office	Amount of the SPM10 is decreasing from January to December of years 2561-2566 B.E. and will be increasing much in years 2570, 2575 and 2580 B.E. However, it tends to much decrease in September.
12. Housing Authority Office of Din Daeng Community	Amount of the SPM10 is decreasing from January to December of years 2561-2566 B.E. and will be decreasing substantially in years 2570, 2575 and 2580 B.E. However, it tends to decrease a lot in August.
13. The Government Public Relations Department	Amount of the SPM10 is increasing from January to December of years 2561-2566 B.E. and will be increasing considerably in years 2570, 2575 and 2580 B.E. The constant trending is in February and June to December.

Table 3 (Continued)

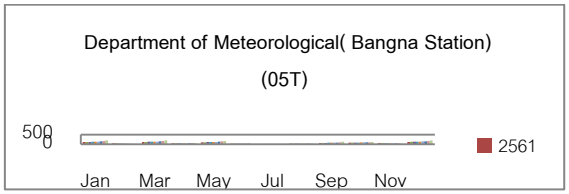
Weather radar stations	Forecast data of amount of the SPM10 in the future
14. Bodindecha School (Sing Singhaseni)	Amount of the SPM10 is increasing from January to December of years 2561-2566 B.E. and will be increasing significantly in years 2570, 2575 and 2580 B.E. The constant trending is in June to December.



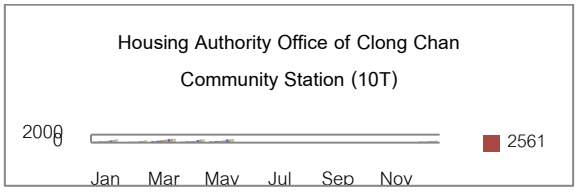
(1) Bansomdejchaopraya Rajabhat University Station



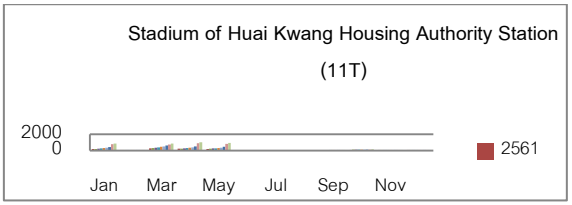
(2) Ratchaburana Post Office Station (Original)



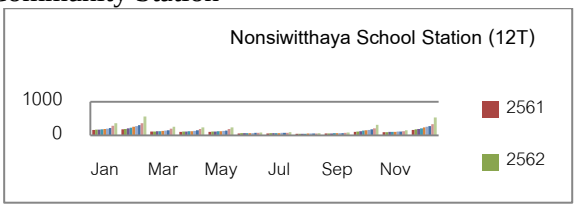
(3) Department of Meteorological (Bangna)



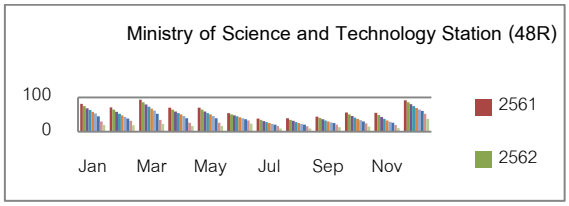
(4) Housing Authority Office of Clong Chan Community Station



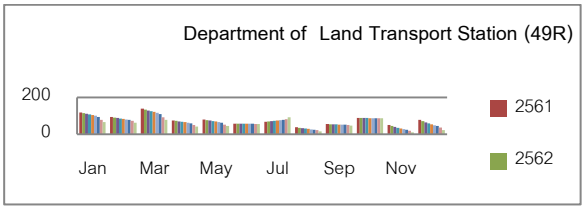
(5) Stadium of Huai Kwang Housing Authority Station



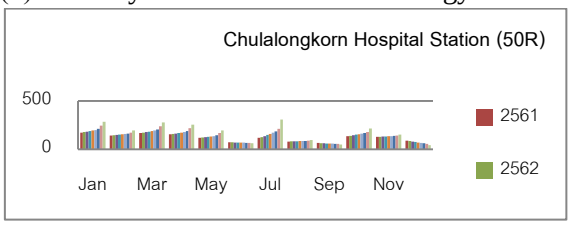
(6) Nonsiwitthaya School Station



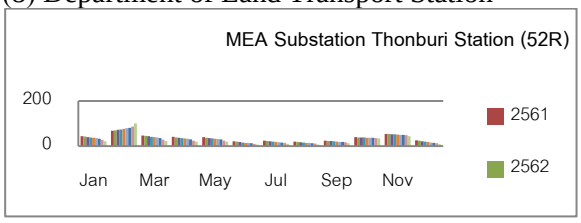
(7) Ministry of Science and Technology Station



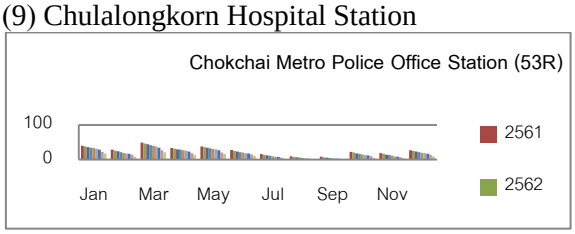
(8) Department of Land Transport Station



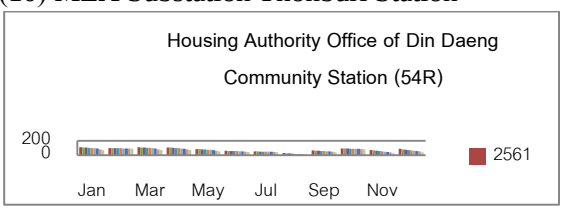
(9) Chulalongkorn Hospital Station



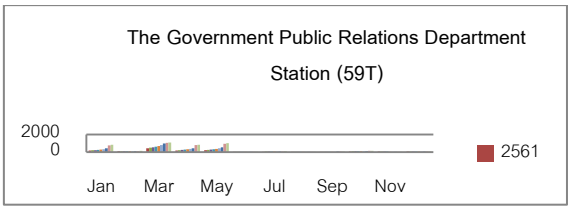
(10) MEA Substation Thonburi Station



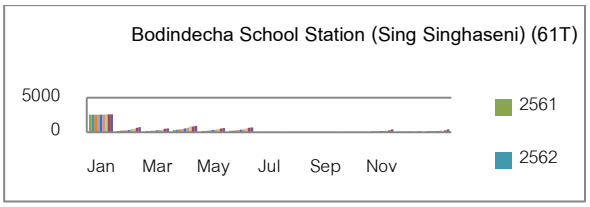
(11) Chokchai Metro Police Office Station



(12) Housing Authority Office of Din Daeng Community Station



(13) The Government Public Relations Department Station



(14) Bodindecha School (Sing Singhaseni) Station

Figure 2 Forecast the amount of the SPM10 in the future of each weather radar station

2.3 Research Result and Discussion: The GM showed that the SPM10 forecast value in Bangkok was close to the real value. The forecast value can be increased, decreased or constant. However, the forecast value of the GM can be used to find the way to support tourism, to encourage tourists to preserve the environment and keep it clean. Also, tourists can work with the community in each province to take care of the air quality, join the campaign of preserving environment by not burning garbage, campaign of planting trees along the roadside in order to let them absorb the air pollution, campaign of keeping any area clean for good scenery, and join any project involved that will decrease amount of the SPM10 in the future. Related research is as follows. Wongphan (2018) stated that the pollution control department has a mission to measure and manage air quality in Bangkok (Pollution Control Department Bangkok, 2017). Standard values affect the health of people and the image of Bangkok, because this capital city is the tourism and economic center of Southeast Asia. Phonviboon *et al*. (2014) claimed that rapid economic growth, enhanced agricultural productivity, and particulate matter of less than 2.5 microns emissions in the northern cities of Thailand have been increasing. Emissions of particulate matter have brought a series of public health concerns, particularly chronic respiratory diseases.

The forecast information amount of the SPM10 in Bangkok showed that there are three trending values that can be compared; such as increasing value, decreasing value and constant value. Therefore, the data can be used as basic information for involved organizations in order to make advantages in economy, society and environment, especially major tourist destination provinces.

1) In Term of Economy: the statistics showed that air quality in Bangkok is still a problem because there is still over standard value every year. Therefore, the government and the private sectors should have a policy to control the amount of the tiny SPM10 to meet the standard and to be safe for health. In addition, all the SPM10 resources should be kept to decrease the SPM10, and an effective air management should be planned. Then there should be tools and air quality examination.

2) In Term of Society: air pollution problem is an important problem of tourist destination cities. The vehicles in big cities have increasing and should be controlled and the motors should be examined. Moreover, there should be a campaign of safe driving and riding in order to keep the image and quality of good life. Then, the society in the tourist destination provinces will be better and health of the population and tourists will be good. Related research is as follows. Rodthanee (2015) found that air conditioning buses had the highest ADI, followed by minibuses, public vans, MRT and BTS, respectively. These may be influenced by other factors, such as getting on and off the vehicles of passengers during the trips, traffic conditions etc. Based on the results, improvement of the vehicles ventilation systems together with cleaning up the vehicles cabins regularly

was suggested, especially in air conditioning buses.

3) In Term of Environment: the amount of suspended particulate matter in Bangkok showed that the SPM10 from the factories in the big cities has an impact on tourism. Therefore, there should be campaigns and projects to manage the environment properly in order to support tourism sustainably and make good image of the country.

CONCLUSION

Use of the GM Model to forecast the amount of suspended particulate matter (SPM10) in Bangkok from 2561-2566 B.E. and suspended particulate matter value in the future can be analyzed and compared as follows.

1. The result of the SPM10 forecast amount showed that the amount of the SPM10 are rising in the following stations; Ratchaburana Post Office Station (Original), Meteorological Department of Bangna Station, Housing Authority Office of Clong Chan Community Station, Stadium of Huai Kwang Housing Authority Station, Nonsiwitthaya School Station, Chulalongkorn Hospital Station, The Government Public Relations Department Station and Bodindecha School Station (Sing Singhaseni). The amount of the SPM10 in the above stations was growing because of the increasing vehicles, with the SPM10 coming from those vehicles. This problem has a direct impact to health. It can cause allergy, pneumonias, cancers, or respiratory diseases and has an impact on the environment.

2. The result of the SPM10 forecast amount indicated that the amount of the SPM10 are reducing in the following stations; Bansomdej chaopraya Rajabhat University Station, Ministry of Science and Technology Station, Department of Land Transport Station, MEA Substation Station, Chokchai Metro Police Office Station, and Housing Authority Office of Din Daeng Community Station. The amount of the SPM10 in the above stations was decreasing because there is good management. For example, big factories have efficient environmental management and give advice to middle and small factories (SMEs) to have friendly manufacturing to environment and community, as well as support to have an association of suspended particulate material groups in order to solve pollution problems in the area. Air pollution values in each station in Bangkok showed that some stations had good values while some had fair values of air quality. This was consistent with the forecast model showing the increasing value.

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