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ESTIMATION OF PM_{10} USING SPATIAL INTERPOLATION TECHNIQUES

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Abstract- Air pollution, especially the haze problem caused by the accumulation of smoke and dust in the air is another important problem in Thailand. Especially at present, this issue has become increasingly serious respectively. This study aimed to study the relationship between Particulate Matter (PM_{10}) content in the southern region and the physical factors of the area and to assess PM_{10} quantity by Spatial Interpolation Techniques, as well as to study the suitability of each method. The results of the study found that the 24-hour mean of the three-year average PM_{10} intake between 2017 to 2019 was the highest in February, with the mean concentration from all measuring stations of 36 µg/m³. It was followed by March, July, and January. The smallest concentration was in October. When analyzing the physical characteristics of the area with high levels of fine dust, it was found that the southern region was characterized by a sharp topography or the land extending into the sea, which was influenced by the southwest monsoon at the south into western Thailand was a major factor in getting dust from wildfires and burning in the open air that was carried by winds from many places, including neighboring countries. Using mean PM_{10} data from six Pollution Control Department (PCD) measuring stations, PM_{10} was assessed by Spatial Interpolation Techniques method using four different methods: Inverse Distance Weighting (IDW), Kriging, Spline, and Trend, it was found that Trend method was the most suitable method for map that showed the distribution of PM_{10} concentration data, especially from January to April with the highest particulate matter.

Keywords: PM_{10}, GIS, IDW, Spline, Trend.

1. INTRODUCTION

Air pollution is one of the major problems in Thailand, specifically nowadays that the problem is becoming more and more serious. There are two main sources of air pollution: the occurrence of air pollution caused by human actions, such as the need for energy for domestic use, industrial use, and agriculture, as well as air pollution that was caused by the use of cars, motor boats, and airplanes, which were the cause of CO_2, NO_2, and hydrocarbons that directly affect human health [1, 2].

The burning of these fuels also caused more and more pollution problems every year. Air pollution problems arising from nature, such as volcanic eruptions, cause large amounts of smoke and ash to spread into the air [3, 4]. Pollution caused by forest fires created haze that was harmful to the respiratory system. Pollution caused by decomposition of fossil plants, chemical reaction would produce CO_2, CH_4, and NH_3 dispersed into the air [5]. Air pollution was caused by dust, which was caused by objects that were smashed, crushed, crushed to shattered into small pieces, when it was exposed to the airflow it disperses in the air. Although the pollution problem cannot be stopped, the results can be analyzed and monitored continuously in order to control the increase in air pollution problems [6]. In each region of Thailand there were identical and different causes of air pollution depending on the terrain and land use [7-10].

For the southern region of Thailand, haze was mainly caused by forest fires and open burning in both the country and neighboring countries [11]. The nature of the incineration of agricultural waste, incineration, this combustion resulted in small dust and various hazardous gases. This caused microscopic particles that affected health, especially PM_{10} content [12-16]. When it entered the body, it caused symptoms that affected the body system, such as coughing, sneezing, and shortness of breath, which caused respiratory disease. Currently, Geographic Information System (GIS) was used as part of the area analysis and air pollution distribution [17-22] due to field repositories, operators cannot store data anywhere of a large area.

When mapping data, gaps in the data may be found, so estimates for missing sections must be estimated using Spatial Interpolation Techniques such as topographic mapping, population density determination, and climate estimate, continue to study relationships in relation to other information [23-27]. This study was to study the relationship between PM_{10} concentration in the southern region and physical factors of the area and to assess PM_{10} quantity by Spatial Interpolation Techniques method. In addition, the study also studied the suitability of Spatial Interpolation Techniques in various ways for the assessment of PM_{10} in southern region by using Geographic information system (GIS) as an operational tool.

The results can be useful in air pollution management and control and provide further support for further studies on air pollution in the area.

2. MATERIAL AND METHOD

2.1. Data Collection

This research collected data from various sources to assess PM_{10} concentrations by Spatial Interpolation Techniques in southern Thailand during 2017, 2018, and 2019 as follows:
(1) PM_{10} concentration data from the Southern region from Pollution Control Department (PCD)
(2) Air quality monitoring station location data from Pollution Control Department (PCD)
(3) Southern region and provincial administrative boundaries in the south from Royal Thai Survey Department.

2.2. Operation Tools

(1) Computer for processing data
(2) Geographic information system (GIS) program
(3) Dust data from the Air4Thai website (http://air4thai.pcd.go.th/webV2/) of the Pollution Control Department (PCD)

2.3. Data Analysis

(1) PM_{10} data were collected from air quality monitoring stations of the Pollution Control Department (PCD), air quality monitoring station location data, southern boundary data, and provincial regions in the south for import into Geographic information system (GIS).
(2) Analyze the relationship between PM_{10} quantity and physical characteristics of the southern region, including location, range of dispersion of PM_{10}, and topography, etc.
(3) Using data obtained from PM_{10} measurements from 6 stations of the Pollution Control Department (PCD) including 1) Narathiwat City Hall, 2) Phuket Municipality Public Health Service Center, 3) Elephant School Ceremony School Station in Yala Province, 4) Hat Yai Municipality Station (Songkhla), 5) the Environment Office Region 14, Surat Thani and 6) Satun City Hall, during 2017 to 2019, Spatial Interpolation Techniques was performed using 4 methods:

Inverse Distance Weighting (IDW): This was an approximation by random sampling of each sample point from a location that can affect the cells that need to be estimated, which will have less of an impact over long distances. This method was suitable for variables referring to the computational distance because the closer it is, the more influence.

Spline: It was a method of inserting values to fit at least the curved surface according to the imported sample data point. It was like twisting a rubber sheet through a sample point trying at least all of the curvature toward those sample points as the surface. Spline method was a mathematical equation suitable for gradual change surfaces.

Kriging: It was an advanced method of estimation by applying statistical processes and mathematical equations to the analysis. This method selects the appropriate mathematical equation with the selected sample point within the specified radius to obtain results for each area. Using Kriging, it was important to know the spatial correlation or direction bias in the Kriging data, which was different from other interpolation methods such as IDW or Spline since both were approximations directly surrounding the sample point.

Trend: This method selected an appropriate mathematical equation by specifying a sequence of algebra (polynomial) to all sample points.

3. RESULT AND DISCUSSION

3.1. Results of the PM_{10} Assessment and their Relationship with the Physical Factors of the Area

From the 24-hour mean PM_{10} 3-year mean, between 2017 to 2019 from the 6 Pollution Control Department (PCD) air quality monitoring stations can be shown as shown in Figure 1. It was found that the three-year average PM_{10} was the highest in February, with the average concentration from all monitoring stations equal to 36.07 μg/m³. It was followed by March, July, and January with concentrations 33.95, 32.34, and 32.22 μg/m³, respectively.

The lowest concentration was in October, with the average concentration from all stations equal to 23.06 μg/m³. When considering the average value for each measuring station, it was found that the Hat Yai Changwat Songkhla Municipality Meteorological Station had the highest average at 32.60 μg/m³. It was followed by the White Elephant School Ceremony School Station in Yala Province, the Environment Office Region 14, Surat Thani Province, and Narathiwat City Hall with a mean of 32.6, 30.87, and 30.27 μg/m³, respectively. In addition, the physical analysis of the area with high levels of fine dust found that the southern region was characterized by a sharp topography or land extending into the sea, which was influenced by the southwest monsoon wind blowing from the south entering western Thailand was therefore an important factor in getting dust from forest fires and burning in the open air that was carried by the wind from many places, including neighboring countries.

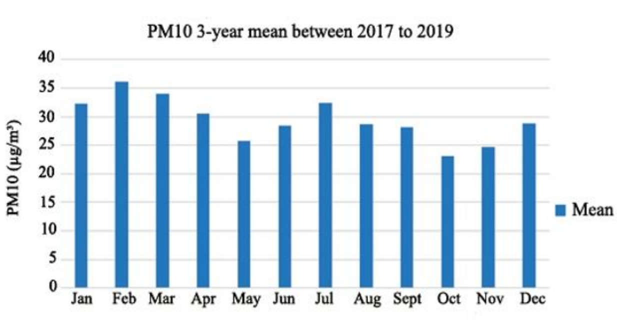


Figure 1. PM_{10} 3-year mean, between 2017 to 2019

3.2. Results of Assessment of PM_{10} Concentration by Spatial Interpolation Techniques

3.2.1. Results of PM_{10} Quantitative Assessment by Spatial Interpolation Techniques from 6 Measuring Stations

The Spatial Interpolation Techniques for PM_{10} using the three-year mean data between 2017 and 2019 from six measuring stations used to validate the data was shown in Table 2, Figure 2 (a,b,c,d) and Figure 3. According to Table 2, Figure 2-3, the spatial estimation of the 3-year average PM_{10} concentrations based on the data of the 6 monitoring stations was the highest in February, followed by March and July as well. The mean obtained from actual measurement was found to be the lowest in October.

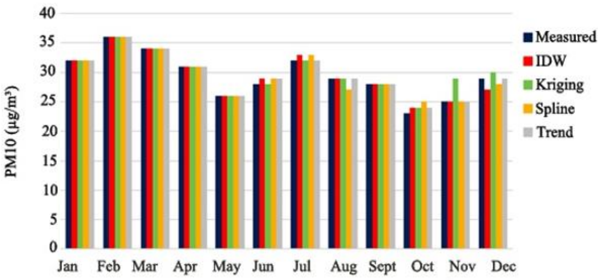
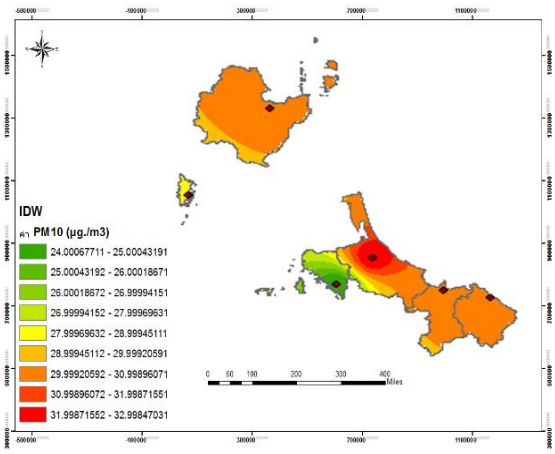
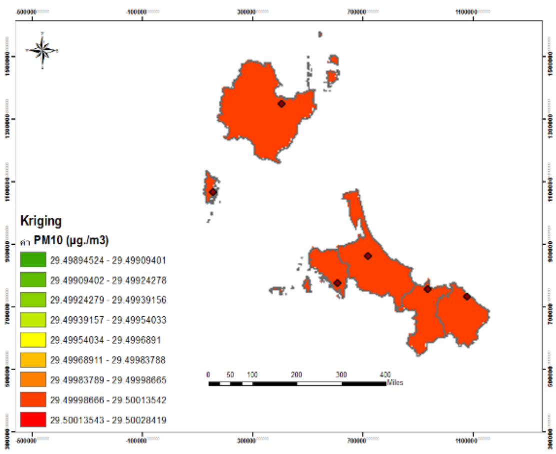


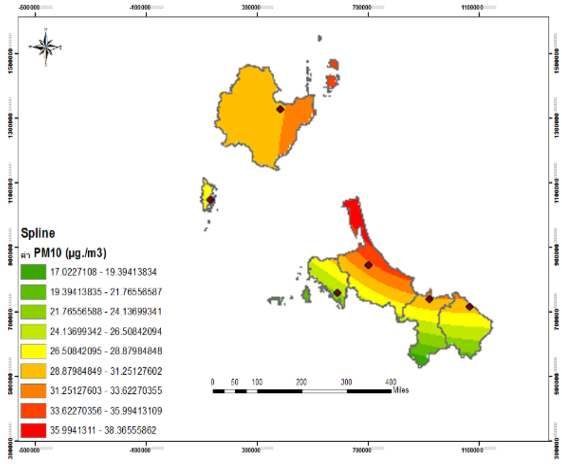
Figure 2. PM_{10} 3-year mean, between 2017 and 2019



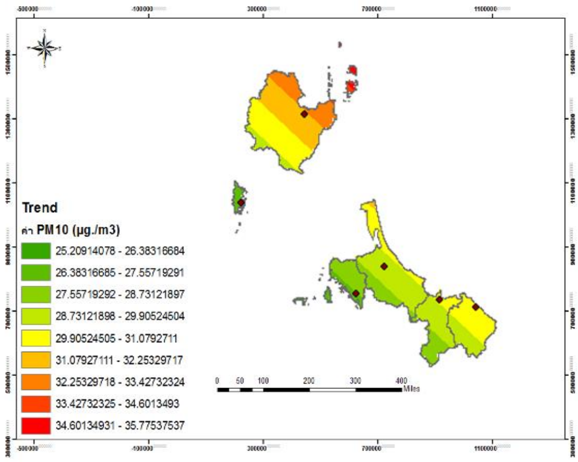
a (IDW)



b (Spline)



c (Kriging)



d (Trend)

Figure 3. Illustration the Spatial Interpolation Techniques from 4 different methods

3.2.2. Difference of Spatial Quantity Versus Actual Measurement

When comparing the PM_{10} quantity data obtained from the six measurement stations with the data from the actual measurement, each station gave different values for different data. In February, it was the month with the highest amount of PM_{10}, which can differentiate each method as shown in Table 1. From Table 1, it was found that when using the PM_{10} quantity data from the 6 Hives Department monitoring stations in the South during 2017-2019 in February to quantify the spatial values by various methods, it was found that Trend method provided the smallest difference and IDW, Kriging, and Spline method gives the greatest difference. Each spatial estimation method gave different values as follows.

The spatial estimation using IDW method had the lowest margin at Narathiwat City Hall Station, Regional Environment Office 14 (Surat Thani) and had the highest margin at Hat Yai Municipality Station (Songkhla).

Spatial estimation by Kriging method had the lowest margin at Narathiwat City Hall Station, Regional Environment Office 14 (Surat Thani) and had the highest margin at Hat Yai Municipality Station (Songkhla). Spline estimation was the lowest at Narathiwat City Hall

Station, Regional Environment Office 14 (Surat Thani) and had the highest difference at Hat Yai Municipality Station (Songkhla). The spatial estimation using Trend method had the lowest margin at the Environmental Office Region 14 Station (Surat Thani) and the highest margin at Hat Yai Municipality Station (Songkhla).

3.2.3. Results of Difference Analysis of Four Spatial Interpolation Techniques (Monthly)

The results of the analysis of the differences of the four Spatial Interpolation Techniques from the total 12-month mean between 2017 and 2019 were shown in Table 2. From Table 2, it was found that when considering the suitability of Spatial Interpolation Techniques from the 12 months of 2017-2019, the four methods were IDW, Kriging, Spline, and Trend, and Trend was an ideal method to map the distribution of PM_{10}. Due to the least difference between the spatial estimation and the actual measurement of 9 months from 12 months, followed by the Spline method of 8 months from 12 months.

3.2.4. Results of Analysis of Differences of Five Spatial Estimation Methods (Seasonally)

The difference in the amount of dust obtained from the estimation to the values obtained from the actual measurements for the whole 12 months when analyzed seasonal with climate difference between 2017 and 2019.

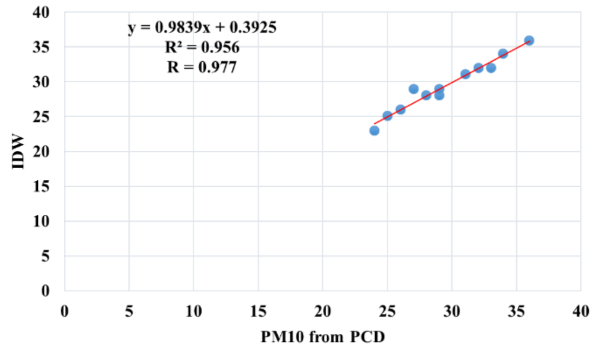
During dry season between January, February, March, and April, there was a large amount of PM_{10}. The study had shown that all methods were most suitable for spatial estimation during this period because the difference was minimal and there was no improper method.

During the rainy season between May, June, July, August, September, and October, where PM_{10} was low, the study found that Kriging method was the most suitable method for spatial estimation in This range, because the difference was minimal. The unsuitable method was the IDW and Spline methods, as they gave the greatest difference during this period.

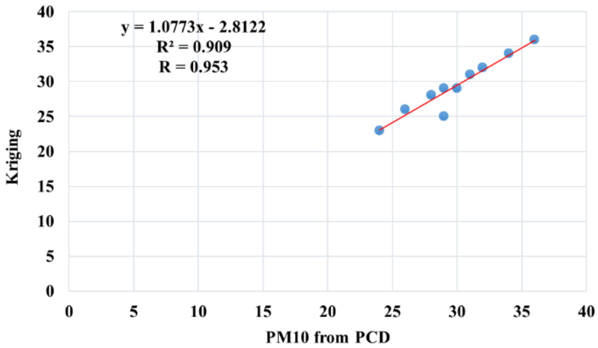
During the cold season between November and December, the amount of PM_{10} increased, the IDW method was found to be the most suitable method for spatial estimation during this period as the difference was minimal. The improper method was the Kriging method, as it gave the most difference during this period.

3.2.5 Statistical Analysis Results by Correlation Analysis and Simple Linear Regression

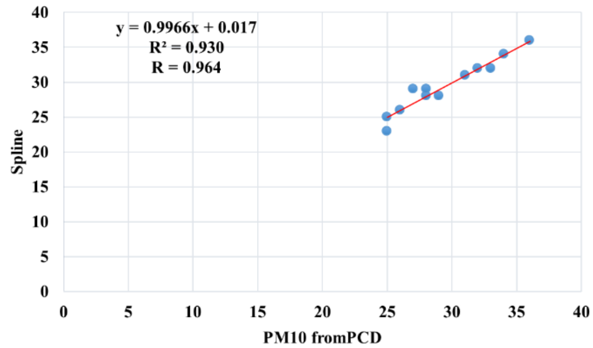
For statistical analysis results using simple linear regression and correlation analysis from the monthly mean of PM_{10} quantity from actual measuring stations in all three years (2017-2019) and PM_{10} concentrations from Spatial Interpolation Techniques with IDW, it was found that the temporal shift of PM_{10} concentrations from actual measuring stations was the most consistent with the PM_{10} concentrations from Spatial Interpolation Techniques with IDW. The relationship between the quantity from the IDW estimation between the actual measuring station and the quantity from the IDW method can be shown in Figure 4.



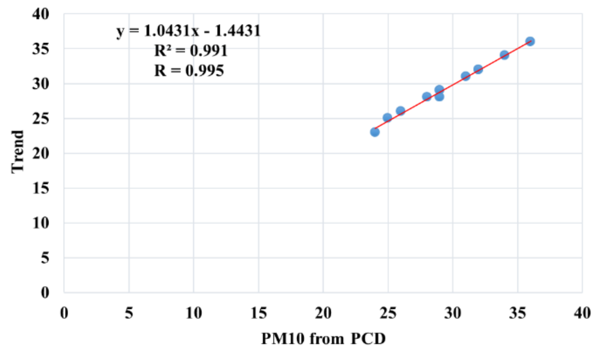
(a) IDW



(b) Kriging



(c) Spline



(d) Trend

Figure 4. Illustration correlation analysis and simple linear regression from 4 different methods

From Figure 4, the relationship between PM_{10} concentration from the actual measuring station and PM_{10} concentration from Spatial Interpolation Techniques with IDW, Kriging, Spline, and Trend can be described as follows.

These two sets of data were analyzed for a simple correlation analysis, which studied the relationship between x and y, how much they were related, and how they were directed when x was an independent variable and y was a dependent variable. In this study, the independent variable (x) was assigned the amount of PM_{10} from the actual measurement station obtained from the ground monitoring station. Variables following (y) PM_{10} from Spatial Interpolation Techniques with IDW, Kriging, Spline, and Trend.

The results of the aforementioned correlation analysis showed that PM_{10} concentrations from actual measurement stations obtained from ground measurement stations were correlated with PM_{10} from Spatial Interpolation Techniques with IDW, Kriging, Spline, and Trend in the same direction 97.78% (R=0.9778), 95.34% (R=0.9534), 96.45% (R=0.9645), and 99.55% (R=0.9955), respectively. When these two sets of data were analyzed using simple linear regression, which analyzes estimates (predictor, x) and response (response, y), it was found that the change in PM_{10} concentration from Spatial Interpolation Techniques by IDW, Kriging, Spline, and Trend. It was caused by a change in PM_{10} quantity from actual measurement values obtained from ground measurement stations approximately 95.62% (R^2=0.956), 90.91% (R^2=0.9091), 93.04% (R^2=0.9304), and (R^2=0.9911), respectively. The remaining 4.58%, 9.09%, 6.96%, and 0.89% were due to other causes.

4. CONCLUSIONS

The study results of the relationship between PM_{10} concentration in the southern region and the physical factors of the area in three-year average during the summer of 2017-2019, from the end of February to March and April, with large amounts of PM_{10} dust. The reason was that the topography was a cape or land extending into the sea, which had been influenced by the southwest monsoon that winds from the bottom to the western part of Thailand. Therefore, this was an important factor in the exposure to dust from forest fires and open burning caused by winds from many places including neighboring countries. The 24-hour mean of the three-year average PM_{10} concentration between 2017 and 2019 was the highest in February and the average concentration from all monitoring stations was 36 µg/m³.

It was followed by March and January with concentrations 34 and 32 µg/m³, respectively. The lowest concentration was in October, with the average concentration from all stations of 23 µg/m³. When using the mean PM_{10} data through the Spatial Interpolation Techniques process, it was found that the values obtained from Spatial Interpolation Techniques by various methods for each month were different. When

considering the suitability of the four methods - IDW, Spline, Kriging, and Trend, it was found that spatial estimation by IDW, Kriging, and Trend was considered the appropriate method (Trend was the most appropriate) to map showing the distribution of PM_{10} concentration data due to slightest difference in measured values from the actual measurements for 9 months out of 12 months.

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Table 1. The difference of spatial quantity versus actual measurement

Measurement stations	PM_{10} from stations	Spatial Interpolation Techniques							
		IDW		Kriging		Spline		Trend	
		Amount of PM_{10}	Difference (+/-)	Amount of PM_{10}	Difference (+/-)	Amount of PM_{10}	Difference (+/-)	Amount of PM_{10}	Difference (+/-)
1. Narathiwat City Hall	30	40	-10	40	-10	40	-10	37	-7
2. Phuket Municipality Public Health Service Center	28	37	-9	37	-9	37	-9	33	-5
3. Elephant School Ceremony School Station	31	38	-7	38	-7	38	-7	36	-5
4. Hat Yai Municipality Station	33	32	1	32	1	32	1	36	-3
5. Environment Office Region 14, Surat Thani	31	41	-10	41	-10	41	-10	42	-11
6. Satun City Hall	24	29	-5	29	-5	29	-5	33	-9
Total			42		42		42		40

Table 2. The difference analysis of the four Spatial Interpolation Techniques

Month	Spatial Interpolation Techniques				PM_{10} From Station	Least different approach	Most different approach
	IDW	Kriging	Spline	Trend			
January	32	32	32	32	32	all method	without
February	36	36	36	36	36	all method	without
March	34	34	34	34	34	all method	without
April	31	31	31	31	31	all method	without
May	26	26	26	26	26	all method	without
June	29	28	29	29	28	Kriging	IDW/Spline/Trend
July	33	32	33	32	32	Kriging/Trend	IDW/Spline
August	29	29	27	29	29	Spline	IDW/Kriging/Trend
September	28	28	28	28	28	all method	without
October	24	24	25	24	23	IDW/Kriging/Trend	Spline
November	25	29	25	25	25	IDW/Spline/Trend	Kriging
December	27	30	28	29	29	IDW	Kriging

REFERENCES

[1] T. Supasri, P. Intra, S. Jomjunyong, S. Sampattagul, "Evaluation of Particulate Matter Concentration by Using a Wireless Sensor System for Continuous Monitoring of Particulate Air Pollution in Northern of Thailand", Journal of Information Technology Research, Vol. 1, No. 2, pp. 65-78, 2018 (in Thai).

[2] N.A. Ragimova, V.H. Abdullayev, "Overview of Modern Concepts in Electric Power Industry", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 45, Vol. 12, No. 4, pp. 43-49, December 2020.

[3] T. Intarat, "Geoinformatics Application on Air Quality Assessment: A Case Study in Chon Buri Province", Burapha Science Journal, Vol. 6, No. 1, pp. 32-40, 2011 (in Thai).

[4] H. Shayeghi, S. Asefi, E. Shahryari, R. Dadkhah Dolatabad, "Optimal Management of Renewable Energy Sources Considering Split-diesel and Dump Energy", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 34, Vol. 10, No. 1, pp. 34-40, March 2018.

[5] R.L. Ray, A. Ibironke, R. Kommalapati, A. Fares, "Quantifying the Impacts of Land-Use and Climate on Carbon Fluxes Using Satellite Data across Texas", U.S. Remote Sensing, Vol. 11, No. 14, p. 1733, 2019.

[6] T. Kong, D. Choi, G. Lee, K. Lee, "Air Pollution Prediction Using an Ensemble of Dynamic Transfer Models for Multivariate Time Series", Sustainability, Vol. 13, No. 3, p. 1367, 2021.

[7] N. Vichit Vadakan, N. Vajanapoom, "Health impact from air pollution in Thailand: current and future challenges", Environ Health Perspect., Vol. 119, No. 5, A197-A198, 2011.

[8] P. Lalitaporn, T. Mekaumnuaychai, "Satellite Measurements of Aerosol Optical Depth and Carbon Monoxide and Comparison with Ground Data", Environmental Monitoring and Assessment, Vol. 192, No. 6, p. 369, 2020.

[9] Greenpeace, "World Air Quality Report", www.greenpeace.org/static/planet4-thailand-stateless/2020/02/91ab34b8-2019-world-air-report.pdf (accessed on 15 January 2021).

[10] J. Nikam, D. Archer, C. Nopsert, "Regulating air quality in Thailand: a review of policies. SEI policy brief. Stockholm Environment Institute", Available online: https://www.sei.org/publications/regulating-air-quality-in-thailand-a-review-of-policies/ (accessed on 30 March 2021).

[11] W. Suriya, P. Chunpang, T. Laosuwan, "Patterns of relationship between PM_{10} from air monitoring quality station and AOT data from MODIS sensor onboard of Terra satellite", Scientific Review Engineering and Environmental Sciences, Vol. 30, No. 2, pp. 236-249, 2021.

[12] H. Choi, S. Melly, J. Spengler, "Intraurban and Longitudinal Variability of Classical Pollutants in Kraków, Poland, 2000-2010, International Journal of Environmental Research and Public Health, Vol. 12, No. 5, pp. 4967-4991, 2015.

[13] E. Chalvatzaki, S.E. Chatoutsidou, H. Lehtomaki, S.M. Almeida, K. Eleftheriadis, O. Hanninen, M. Lazaridis, "Characterization of Human Health Risks from Particulate Air Pollution in Selected European Cities", Atmosphere, Vol. 10, No. 2, pp. 96, 2019.

[14] S. Zhong, Z. Yu, W. Zhu, "Study of the Effects of Air Pollutants on Human Health Based on Baidu Indices of Disease Symptoms and Air Quality Monitoring Data in Beijing, China", International Journal of Environmental Research and Public Health, Vol. 16, No. 6, pp. 1014, 2019.

[15] L. Levei, M.A. Hoaghia, M. Roman, L. Marmureanu, C. Moisa, E.A. Levei, A. Ozunu, O. Cadar, "Temporal Trend of PM_{10} and Associated Human Health Risk over the Past Decade in Cluj-Napoca City, Romania", Applied Sciences, Vol. 10, No. 15, pp. 5331, 2020.

[16] L. Adamkiewicz, K. Maciejewska, K. Skotak, M. Krzyzanowski, A. Badyda, K. Juda-Rezler, P. Dąbrowiecki, "Health-Based Approach to Determine Alert and Information Thresholds for Particulate Matter Air Pollution", Sustainability, Vol. 13, No. 3, pp. 1345, 2021.

[17] P. Soytong, R. Perera, "Use of GIS Tools for Environmental Conflict Resolution at Map Ta Phut Industrial Zone in Thailand", Sustainability, Vol. 6, No. 5, pp. 2435-2458, 2014.

[18] C.I. Alvarez Mendoza, A.C. Teodoro, N. Torres, V. Vivanco, "Assessment of Remote Sensing Data to Model PM_{10} Estimation in Cities with a Low Number of Air Quality Stations: A Case of Study in Quito, Ecuador. Environments, Vol. 6, No. 7, pp. 85, 2019.

[19] X.N. Bui, C.W. Lee, H. Nguyen, H.B. Bu, N.Q. Long, Q.T. Le, V.D. Nguyen, N.B. Nguyen, H. Moayedi, "Estimating PM_{10} Concentration from Drilling Operations in Open-Pit Mines Using an Assembly of SVR and PSO", Applied Sciences, Vol. 9, No. 14, pp. 2806, 2019.

[20] N. Chen, M. Yang, W. Du, M. Huang, "$PM_{2.5}$ Estimation and Spatial-Temporal Pattern Analysis Based on the Modified Support Vector Regression Model and the 1 km Resolution MAIAC AOD in Hubei, China", ISPRS International Journal of Geo-Information, Vol. 10, No. 1, pp. 31, 2021.

[21] L.K. Widya, C.Y. Hsu, H.Y. Lee, L.M. Jaelani, S.C.C. Lung, H.J. Su, C.D. Wu, "Comparison of Spatial Modelling Approaches on PM_{10} and NO_2 Concentration Variations: A Case Study in Surabaya City, Indonesia", International Journal of Environmental Research and Public Health, 2020, Vol. 17, No. 23, pp. 8883, 2020.

[22] P. Pradabmook, T. Laosuwan, "The Integration of Geo-informatics Technology with Universal Soil Loss Equation to Analyze Areas Prone to Soil Erosion in Nan Province", ARPN Journal of Engineering and Applied Sciences, Vol. 16, No. 8, pp. 823-830, 2021.

[23] M. Curtarelli, J. Leao, I. Ogashawara, J. Lorenzzetti, J. Stech, "Assessment of Spatial Interpolation Methods to Map the Bathymetry of an Amazonian Hydroelectric Reservoir to Aid in Decision Making for Water

Management", ISPRS International Journal of Geo-Information, Vol. 4, No. 1, pp. 220-235, 2015.
[24] A.D. Piazza, F.L. Conti, F. Viola, E. Eccel, L.V. Noto, "Comparative Analysis of Spatial Interpolation Methods in the Mediterranean Area: Application to Temperature in Sicily", Water, Vol. 7, No. 5, pp. 1866-1888, 2015.
[25] M. Wang, G. He, Z. Zhang, G. Wang, Z. Zhang, X. Cao, Z. Wu, X. Liu, "Comparison of Spatial Interpolation and Regression Analysis Models for an Estimation of Monthly Near Surface Air Temperature in China. Remote Sensing, Vol. 9, No. 12, p. 1278, 2017.
[26] P.K. Srivastava, P.C. Pandey, G.P. Petropoulos, N.N. Kourgialas, V. Pandey, U. Singh, "GIS and Remote Sensing Aided Information for Soil Moisture Estimation: A Comparative Study of Interpolation Techniques". Resources, Vol. 8, No. 2, p. 70, 2019.
[27] B. Usowicz, J. Lipiec, M. Lukowski, J. Slominski, "Improvement of Spatial Interpolation of Precipitation Distribution Using Cokriging Incorporating Rain-Gauge and Satellite (SMOS) Soil Moisture Data", Remote Sensing, Vol. 13, No. 5, p. 1039, 2021.

BIOGRAPHIES

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