

# A Synergy of Geographic Information System in the Investigation of Air Pollution Caused by Automobiles in Mueang Chon Buri and Sriracha Districts, Chon Buri Province, Thailand

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**Abstract:** - This research aims to examine the distribution and factors contributing to air pollution caused by automobiles, analyze areas at risk of air pollution, and investigate the effects of air pollution caused by automobiles in Mueang Chon Buri District, and Sriracha District, Chon Buri Province by applying the Geographic Information System (GIS) to estimate the interpolation and Inverse Distance Weighted (IDW) methods. In the research process, the researchers used the location data of 3 Air Quality Monitoring stations in Chon Buri Province, namely the air quality monitoring stations in ThungSukla Subdistrict, Bowin Subdistrict, and Ban Suan Subdistrict, and employed the data on gases that cause air pollution, two types of gases, carbon monoxide sulfur dioxide for the result analysis and evaluation. It is found that the entire district of Mueang Chon Buri and Sriracha District has a total area of approximately 879.364 square kilometers wherein the distribution of carbon monoxide gas and sulfur dioxide is found in large quantities. In addition, the analysis of air pollution risky areas in both districts indicates that there are sources of air pollution scattered along traffic lights, intersections, 80 intersections, 13 parking lots, 90 garages, 281 industrial factories, 156 major roads, and 5,866 minor roads, while the most affected by air pollution are health and environmental impacts ( $\bar{x} = 3.55$ ).

**Key-Words:** - Air pollution, Automobiles, Geographic Information System

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## 1 Introduction

Currently, Thailand and many countries around the world are facing air pollution problems. The cause of air pollution can be caused by nature such as dust problems from wind storms, volcanic eruptions, earthquakes, forest fires, and natural gas, and, another is caused by human actions such as pollution caused by cars, industries, machinery, and construction, etc., [1]. However, polluted air caused by nature has little effect and poses no danger to humans because the source of the problem is far away and the amount of pollutants entering the environment of humans and animals is minimal. Meanwhile, the pollution caused by human activities, such as from car exhaust pipes, industrial plants, production processes, agricultural activities, and evaporation of some gases caused by solid waste and waste can cause more harm to humans. Such pollution will affect human health in a wide range like allergies, respiratory diseases, and

circulatory diseases which in the long term, it may cause death, [2].

Chon Buri Province is an economically important province of Thailand. It is located in the Eastern Economic Corridor (EEC), having outstanding physical and social characteristics with harbors, link of transportation system both by lands, sea, and air to upgrade the economy and competitiveness of the country, heading towards being a center for both trade and investment. In addition, there are many heavy and light industries in the area of Chon Buri Province, [3], which may result in air pollution. In 2022, the results of air quality measurement in Chon Buri province indicated that the amount of particulate matter less than 2.5 microns ( $PM_{2.5}$ ) is 38 micrograms per cubic meter ( $\mu g/m^3$ ), in the moderate quality criteria. Based on Air Quality Index Measurement Results in Chon Buri Province of the Office of the Environment Region 13 (Chon Buri), Pollution Control Department, it was found that the weather

in Ban Suan Subdistrict, Mueang Chon Buri District has a  $PM_{2.5}$  value of 38 micrograms per cubic meter. As for the results of air quality measurements in Bowin Subdistrict, Sriracha District, it is 36 micrograms per cubic meter. Like ThungSukla Subdistrict, Sriracha District,  $PM_{2.5}$  is at 45 micrograms per cubic meter, which is in the moderate quality criteria according to the criteria of the Air Quality Index (AQI), [4], and, it tends to continue to increase and affect human health and living beings for a long term, [5].

Hence, the present study aims at integrating the knowledge and efficiency of the Geographic Information System (GIS) to apply and study the distribution of air pollution caused by vehicles. The findings of this study will be useful for investigating areas at higher risk of pollution in Muang Chon Buri and Sriracha District Chon Buri Province leading to an assessment of the impact of various hazards of pollution. The way GIS works will allow data to be stored as a database, building data layers to create a map showing the distribution and a map showing the areas at risk of air pollution caused by vehicles more clearly. Also, this research provides useful information about the distribution and factors caused by pollution by automobiles. As a result, it is possible to analyze the risky areas in Sriracha District and Mueang Chon Buri District, Chon Buri Province. When there is data on the effects of air pollution caused by automobiles in the district, it will allow agencies at the district and provincial levels to apply it as preventive measures, propose governmental policies for further solutions, and regulate stricter control to care for public health as such.

## 2 Literature Review

Air pollution refers to an air conditioner that contains impurities or floating in the air that we inhale. Even though it may not be visible, such as dust, natural gas, or pollution from car exhaust pipes, etc., it is considered a threat to our physical body that can create a lot of impact and danger to our health, [6].

Air pollution doesn't just happen in crowded big cities or industrial areas conversely, but it can spread across regions of the country quickly. According to the World Health Organization (WHO), air pollution causes up to 7 million deaths each year, with 9 out of 10 people worldwide breathing contaminated air each year. With a high level of pollution constantly entering the body, even with a strong immune system when inhaling toxic air for a long time, it also affects the body because

the dust molecules are as small as  $PM_{2.5}$ . They can enter the body easily as they are so tiny that the nose hairs cannot trap these droplets. It can cause stroke, heart disease, chronic obstructive pulmonary disease (COPD), lung cancer, and acute infections of the upper respiratory tract.

The study, [7], concluded that the causes of air pollution can be divided into 3 parts:

1. It occurs from daily life activities in the house.
2. It occurs in industrial plants and transportation.
3. It occurs from natural disasters.

Primarily in this study, most of the problems of air pollution from transportation vehicles will be studied which in one automobile can release a lot of waste both in the form of smoke gas and soot powder. All of them are air pollutants. Most of the gas emitted from cars is carbon monoxide (CO), a pollutant that causes white smoke. It is a colorless, tasteless, and odorless gas, slightly lighter than normal air. When inhaled, this gas binds hemoglobin in the red blood cells, preventing the transport of oxygen from the lungs to the tissues.

Sulfur dioxide ( $SO_2$ ) is a colorless gas that is not flammable at high concentrations. There will be a pungent odor when reacting with oxygen gas in the air causing damage to the respiratory system such as chronic bronchitis. It also makes the rain more acidic as a result, of the destruction of ecosystems, forests, water sources, and living organisms, including erosion of buildings and ancient sites, [8].

Carbon dioxide ( $CO_2$ ) is the most abundant gas and the main cause of greenhouse gases. There are many causes, including the combustion of fuel, and its appearance as a colorless, odorless, non-flammable gas, but if the body receives large amounts of carbon dioxide, the blood will be acidic. As a result, it stimulates the respiratory system, making breathing faster, so the heart beats fast and suppresses the brain to cause unconsciousness, [9].

Nitrogen oxides ( $NO_x$ ) are caused by the combustion of various types of fuel at high temperatures. It has a chemical composition of nitrogen and oxygen in different ratios, colorless, and odorless, when interacting with other substances such as volatile organic compounds and nitric acid. It will affect the respiratory system, including the human lungs, [10].

Hydrocarbons (HC) are fuel molecules that do not burn at full efficiency. It is not a direct threat to life and health. But it is dangerous when combined until it reacts with nitrogen oxides ( $NO_x$ ), causing the phenomenon of photochemical smog.

Lead compounds (Tetraethyl Lead) have the chemical formula of  $Pb(C_2H_5)_4$ . Petrol manufacturers add lead compounds, known in English as tetraethyl lead, as a liquid to gasoline and motor oil used with the engine to have a high octane or octane bumper and high running speed, preventing the engine convulsions or antiknock additive substance. As the combustion in the engine's computer operator is incomplete, there will be lead compounds coming out. This lead will make the air dirty by spreading in the air throughout the area. As the number of cars in Bangkok or major cities increases, the compounds of lead increase in the shadows of car smoke, although it does not pose an immediate danger to humans when inhaled until it accumulates in the body in large quantities. It also causes global temperature changes from the accumulation of toxic gases in the air to destroy the ozone layer of the world. To reduce this pollution, using private cars sparingly is another way that the whole world prioritizes, so that the world still has fresh air and a temperature that is suitable for humans, [11].

The Department of Land Transport raises the intensity of measures to solve the problem of small particulate matter, and air pollution in accordance with the standards for good public health to tighten the black smoke measurement of trucks and buses across the country, increasing the rigor of vehicle inspections. As a result, in the fiscal year 2021, the number of vehicles detected with black smoke is reduced, moving forward to promote the use of clean energy vehicles to reduce air pollution sustainably.

Mr. Chirut Wisalchit, Director-General of the Department of Land Transport, revealed that the air quality in Thailand has serious carcinogens, especially in Bangkok and its vicinity which is caused by the combustion of diesel engines, mainly from the use of Euro 1-3 oil which is prohibited around the world but has been used in Thailand. In addition, in Thailand, there is a problem of neglecting the punishment measures for black smoke emissions from cars and industrial plants. The Department of Land Transport reaffirms measures for cars using internal combustion engines such as gasoline, compressed natural gas, and diesel engines to emit pollution after combustion of fuel containing gases and particulate matter such as  $CO_2$ , CO, HC,  $SO_x$ ,  $NO_x$ , and PM, etc., which must not exceed the specified standards. Therefore, at present, all new diesel cars that will be registered at the Department of Land Transport must have emission values in accordance with the mandatory standards of the Thai Industrial Standards Institute,

with small diesel cars meeting the Euro 4 standard and above, and large diesel meets Euro 3 standards and above. For cars that are in use, the Ministry of Natural Resources and Environment by the Pollution Control Department has announced the black smoke standard used for inspection of both old and new cars, which must have an opacity of not more than 45 percent. However, vehicles that do not meet the above criteria will be subject to annual vehicle tax renewals, and failure to pass the vehicle inspection, and the car owner must take corrective action immediately to solve the problem of pollution and small dust  $PM_{2.5}$ . The National Environment Board has resolved to enforce emission standards from new cars Euro 5 by 2024 Euro 5 engine standards which require oil with sulfur levels to prevent clogging of pollution equipment. This is necessary to set fuel quality standards equivalent to Euro 5 standards as well. The National Environment Board therefore resolved to enforce the Euro 5 equivalent oil standard from 1 January 2024 onwards.

### 3 Findings

This research is carried out as follows:

1. The study of the distribution and factors causing air pollution by automobiles in Chon Buri Province
  - 1.1 The researchers collect the data on factors that cause air pollution by automobiles, including smoke emitted from cars as follows:
    - 1.1.1 Carbon monoxide gas
    - 1.1.2 Nitrogen sulfur dioxide
  - 1.2 The researchers collect the data from 3 air quality monitoring stations in Chon Buri province as follows:
    - 1.2.1 Thung Sukla Subdistrict Station, Sriracha District, Chon Buri Province
    - 1.2.2 Bo Win Subdistrict Station, Sriracha District, Chon Buri Province
    - 1.2.2 Ban Suan Subdistrict Station, Mueang Chon Buri District, Chon Buri Province
  - 1.3 The researchers collect the air pollution data for the year 2017-2021 from the website of the Air Quality and Noise Management Division, Pollution Control Department to investigate the distribution of air pollution.
  - 1.4 The researchers analyze the distribution and factors causing air pollution by automobiles in Chon Buri province by using the Interpolation, Inverse Distance Weighted (IDW) method, and ArcMap program to examine the distribution of air pollution.

- 1.5 The researchers map the distribution and factors that cause air pollution caused by cars in Sriracha District and Mueang Chon Buri District, Chon Buri Province.
2. Study of risky areas of air pollution caused by cars in Sriracha District and Mueang Chon Buri District, Chon Buri Province
  - 2.1 The researchers collect the data on the areas at risk of pollution caused by cars from the following areas:
    - 2.1.1 Intersection of traffic lights
    - 2.1.2 Garages or public car parks
  - 2.2 The researchers analyze by selecting areas that are at risk of air pollution caused by cars.
  - 2.3 The researchers study the behavior of the risky areas to determine which factor is caused.
  - 2.4 The researcher prepared a map showing the areas at risk of air pollution caused by cars in Sriracha District and Mueang Chon Buri District, Chon Buri Province.
3. Study on the effects of air pollution caused by cars in Sriracha District and Mueang Chon Buri District, Chon Buri Province.
  - 3.1 The researchers collect data on the impact of air pollution caused by cars, including a sample population in terms of health, such as households in 11 districts affected by the environment and health. This is carried out by using the formula of Taro Yamane (Taro Yamane) population living in Chonburi province totaling 1,583,633 people (Provincial Administration, Chonburi Province), which determines the sample group by using the calculation principle with the formula of [13], at a confidence level of 95%, an error of 5%.

Analysis of data distribution and factors contributing to air pollution caused by automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province distribution and factors in the form of a map are as follows:

1. Distribution map and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2017, as shown in Figure 1. The distribution and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province, 2017 are presented in Appendix Table 1.

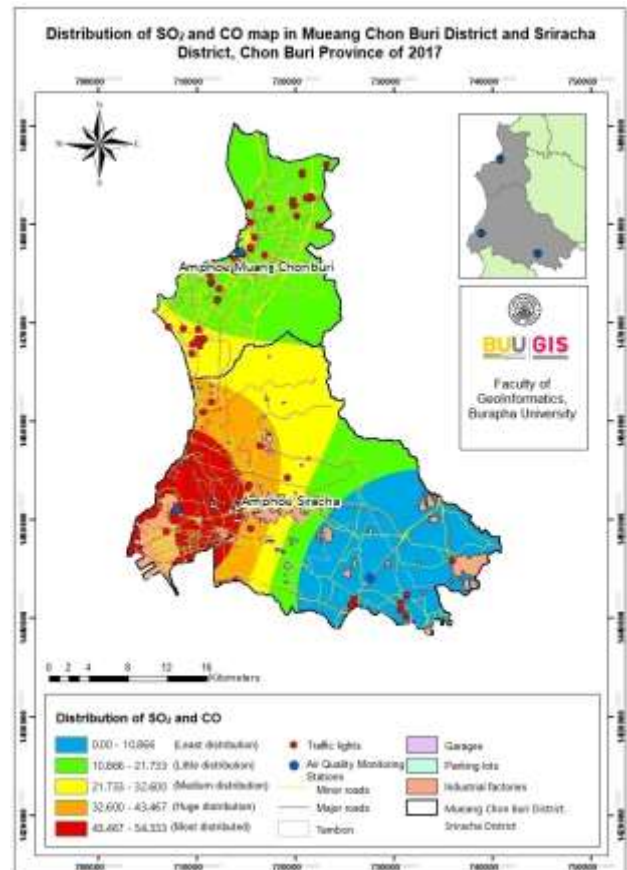


Fig. 1: Distribution map and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2017

2. Distribution map and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2018, as shown in Figure 2. The distribution and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2018 are presented in Appendix Table 2. Similarly, the distribution and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2019 are presented in Appendix Table 3. Furthermore, the distribution and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2020 are presented in Appendix Table 4.

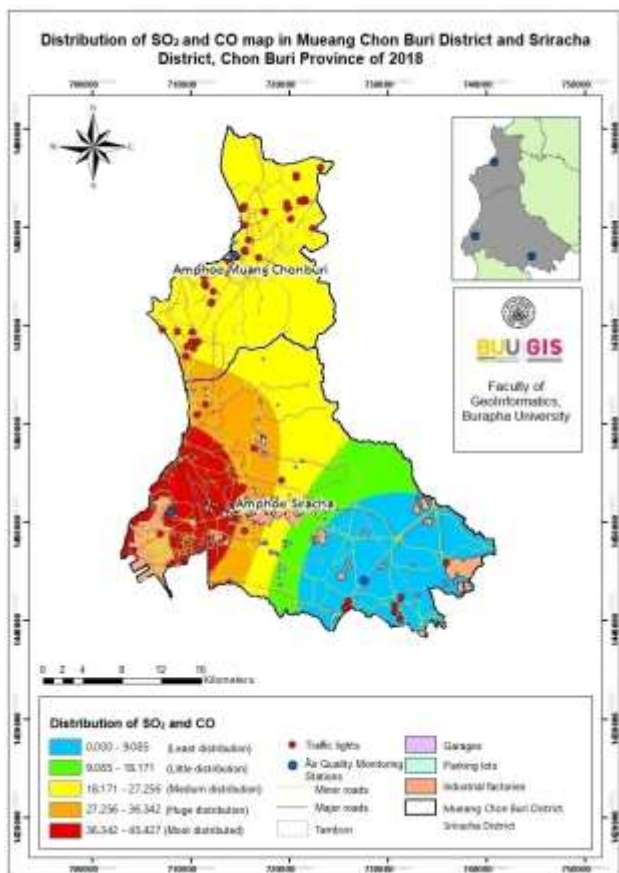


Fig. 2: Distribution map and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2018

3. Distribution map and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2019, as shown in Figure 3.

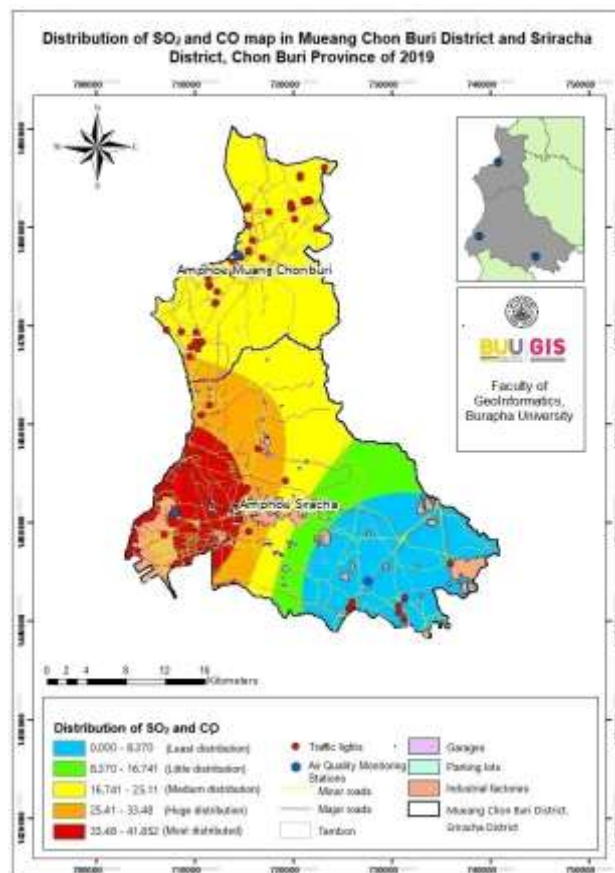


Fig. 3: Distribution map and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2019

4. Distribution map and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2020, as shown in Figure 4.



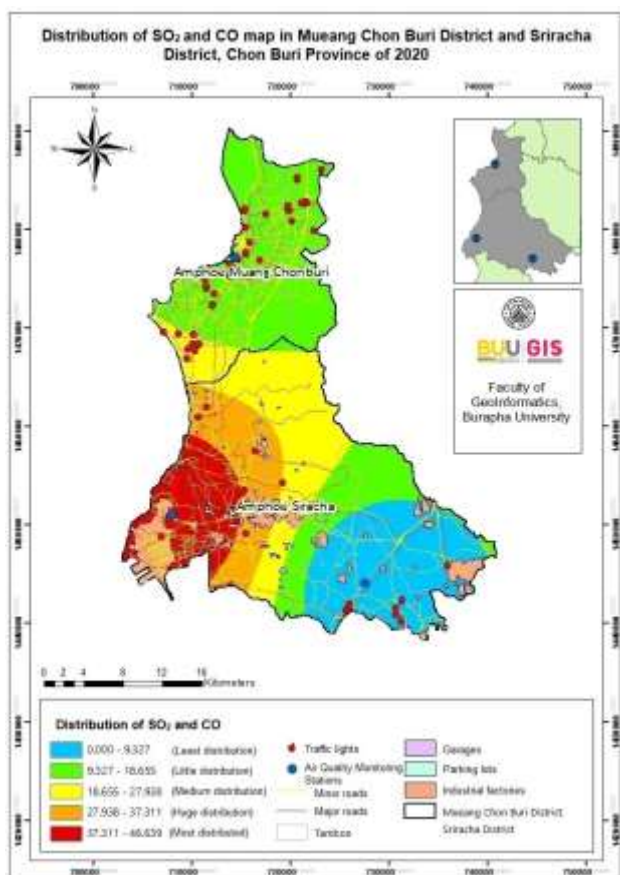


Fig. 4: Distribution map and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2020

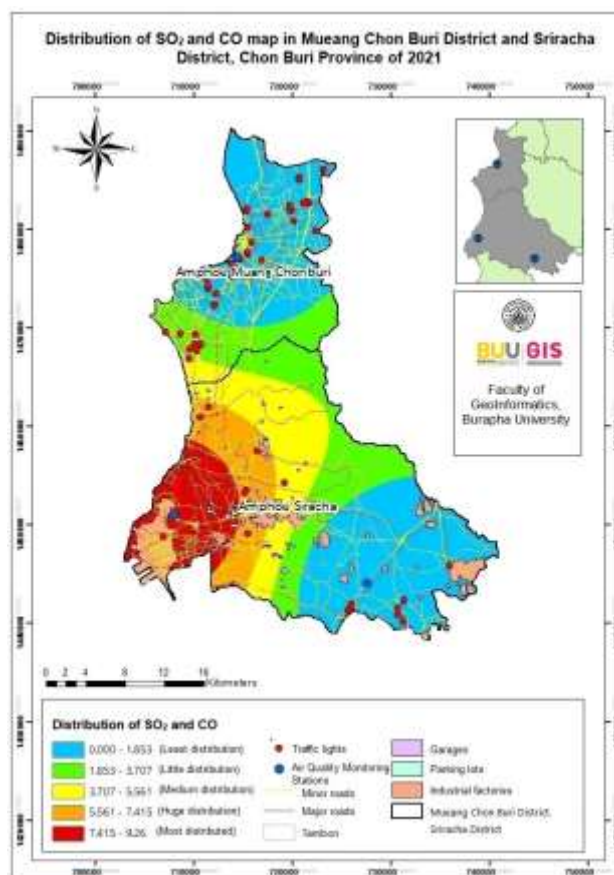


Fig. 5: Distribution map and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2021

5. Distribution map and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2021, as shown in Figure 5. The distribution and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2021 are presented in Appendix Table 5.

The analysis of the areas at risk for air pollution caused by cars in Chon Buri province in the form of a map includes:

1. Map of risky areas that cause air pollution from automobiles, Sriracha District, Chon Buri Province.

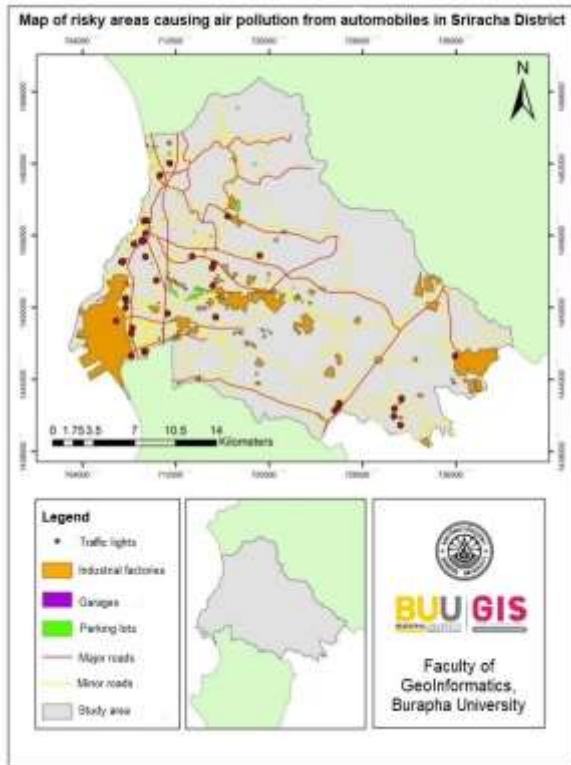


Fig. 6: Map of risky areas causing air pollution from automobiles in Si Racha District, Chon Buri Province

2. Map of the areas at risk that cause air pollution from automobiles, Mueang Chon Buri District Chon Buri Province

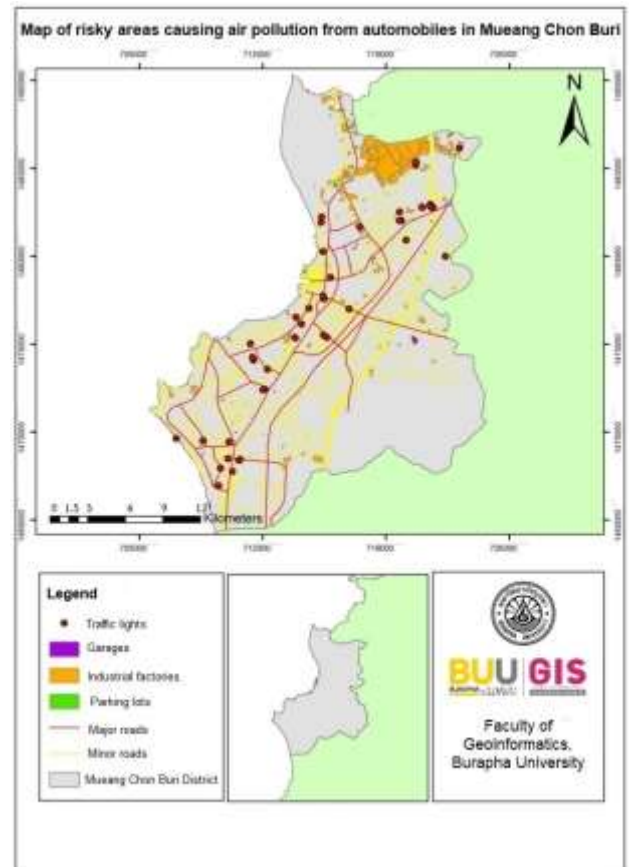


Fig. 7: Map of risky areas causing air pollution from automobiles, Mueang Chon Buri District Chon Buri Province

3. Map of the areas at risk that cause air pollution from automobiles, Mueang Chon Buri District and Sriracha District, Chon Buri Province

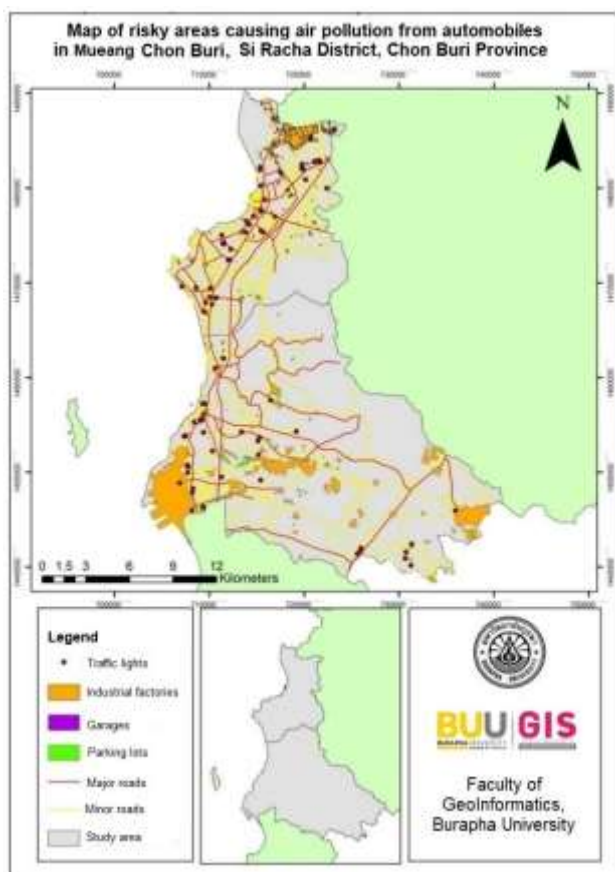


Fig. 8: Map of risky areas causing air pollution from automobiles, Mueang Chon Buri District and Sriracha District, Chon Buri Province

3134, Bangsaen-Ang Sila Road, Saen Suk Road, National Highway No. 3129, National Highway No. 3241, National Highway No. 3138, National Highway No. 3144, Sukprayoon Road, Akniwat Road, National Highway No. 315, National Highway No. 331, National Highway No. 344, National Highway No. 34 Parking Area 138 cars, 90 garages and 281 industrial factories, respectively.

The researchers analyzed the impact of air pollution caused by automobiles in Chon Buri Province by using a statistical analysis program for the mean and percentage that caused the effect by using accidental sampling, [12], according to the proportion of the population of Mueang Chon Buri District and Sriracha District until the total size of the calculated sample is 400 sets. The researchers then analyzed the sample population in the two districts affected by health and the environment by using the calculation formula of Taro Yamane, [13], which includes the population living in Mueang Chon Buri District and Sriracha District a total of 662,051 people (Chon Buri Provincial Administration) at a confidence level of 95% with a discrepancy of 5%, as shown in Table 6, Table 7, and Table 8.

#### Health impact ( $\bar{x} = 3.55$ )

## 4 Results of Data Analysis

From the analysis of the areas at risk of air pollution caused by cars in Mueang Chon Buri District and Sriracha District Chon Buri Province during the year 2017-2021, it shows that there are 42 intersections of risky areas found in Mueang Chon Buri District. The district's air pollution risky areas include 73 main roads, 3,239 minor roads, 97 parking lots, 73 garages, and 194 industrial factories. As for the risky areas in Si Racha District, it reveals that they are scattered along all 38 traffic lights intersections, consisting of 83 main roads, 2,627 minor roads, 41 parking lots, 17 garages, and 87 industrial factories.

While the results of the analysis of air pollution risky areas both in Mueang Chon Buri District and Sriracha District Chon Buri province, it shows that they are scattered along all 80 traffic lights intersections, consisting of 156 main roads and 5,866 minor roads, including Bang Saen Road, Sai 2 Road, Long Hat Bang Saen Road. Lower Bangsaen Road, Sukhumvit Road, National Highway No. 7, National Highway No. 3, Lower Bangsaen Road National Highway No. 3466 National Highway No.



Table 6. Analyzed data indicating the effect on the health of the population in the areas investigated.

Health Effects	Impact Level (People)					
	None	little	moderate	most	The most	total
1. Lung disease and allergies are caused by pollution emitted from car fumes. ( $\bar{x} = 3.70$ )	5	39	144	96	116	400
<b>Percentage</b>	1.3	9.7	36	24	29	<b>100</b>
2. Caused by smoking inhaling car fumes, causing respiratory illnesses such as coughing, runny nose, and colds. ( $\bar{x} = 3.58$ )	3	35	123	205	34	400
<b>Percentage</b>	0.7	8.8	30.8	51.2	8.5	<b>100</b>
3. Occurrence of eye irritation due to the occurrence of gases released from car fumes. ( $\bar{x} = 3.53$ )	3	39	136	188	34	400
<b>Percentage</b>	0.8	9.7	34	47	8.5	<b>100</b>
4. Sickness in the skin system such as a rash on the skin and blisters on the skin caused by allergies. ( $\bar{x} = 3.40$ )	9	46	152	163	30	400
<b>Percentage</b>	2.3	11.5	38	40.7	7.5	<b>100</b>

**Environmental impact ( $\bar{x} = 3.70$ )**

Table 7. Data survey on the environmental impact caused by natural phenomena.

Environmental impact (Occurrence by nature)	Impact Level (people)					
	None	little	moderate	most	The most	total
1. It is caused by hot weather conditions that most people use vehicles to commute. ( $\bar{x} = 3.84$ )	1	21	114	170	94	400
<b>Percentage</b>	0.3	5.3	28.5	42.5	23.5	<b>100</b>
2. It is caused by the wind blowing gases from car smoke into the air that the air is polluted by various gases that come out of vehicles. ( $\bar{x} = 3.59$ )	1	36	136	179	48	400
<b>Percentage</b>	0.3	9	34	44.8	12	<b>100</b>

Table 8. Data survey on the environmental impact caused by a man-made environment.

Environmental impact (Occurrence by human hand)	Impact Level (people)					
	None	little	moderate	most	The most	total
1. It originated from an industrial plant ( $\bar{x} = 3.72$ )	1	22	128	187	62	400
<b>Percentage</b>	0.3	5.5	32	46.7	15.5	<b>100</b>
2. It is caused by transportation or various types of vehicles ( $\bar{x} = 3.65$ )	4	25	131	185	55	400
<b>Percentage</b>	1	6.3	32.8	46.3	13.6	<b>100</b>

Data on the impact of air pollution caused by automobiles on people was obtained from a questionnaire with a rating scale of 5 levels, i.e., the most impact 5 points, very much impact 4, moderate impact 3, less impact 2, and 1 for no impact. The researchers applied statistical calculations with frequency, percentage, and mean for each subsection of each impact aspect. The results of the analysis of the opinions of the respondents were used to define the criteria for interpreting the level of impact obtained from the range of average scores as follows (Table 9):

Table 9. Level of impact, [14]

Impact Level	Average Score Range
Most impact	4.51 – 5.00
Very much impact	<b>3.51 – 4.50</b>
Moderate impact	2.51 – 3.50
Less impact	1.51 – 2.50
No impact	1.00 – 1.50

When considering the impact of air pollution caused by transport vehicles the questionnaire shows that people face health problems and the environment at a high level ( $\bar{x} = 3.55$ ). Notably, analysis of the results of the two polluting gas values in this study is presented in the form of a graph since the year 2017-2021, which is divided into 3 periods:

08.00-12.00 hrs., 12.00-16.00 hrs., and 16.00-20.00 hrs., as shown in Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, Figure 9.

When considering the above information, it reveals that in the year 2017, carbon monoxide gas is at the highest value of about 0.6 microns during 08.00-12.00 hrs. and the lowest value is 0.5 microns during 12.00-16.00 sulfur dioxide. The highest value is about 2.7 microns during 12:00-16:00 and the lowest value is 1.3 microns during 12:00-16:00.

In the year 2018, it was found that carbon monoxide gas is at the highest value of about 0.7 microns during 08.00-12.00 hrs. and the lowest value is 0.6 microns during 12.00-16.00 sulfur dioxide. The highest value is about 2.7 microns from 8:00 a.m. to 12:00 noon and the lowest value is 0.5 microns from 8:00 a.m. to 12:00 noon.

In the year 2019, it was found that carbon monoxide gas is at the highest value of about 0.7 microns during 08.00-12.00 hrs. and the lowest value is 0.5 microns during 12.00-16.00 sulfur dioxide. The highest value is about 1.8 microns during 12:00-16:00 and the lowest is 1.3 microns during 08:00-12:00.

In the year 2020, it was found that carbon monoxide gas at the highest value of about 2.4 microns during 12.00-16.00 hrs. and the lowest value is 0.5 microns during 08.00-12.00 sulfur dioxide. The highest value is about 1.8 microns during 12:00-16:00 and the lowest is 1.3 microns during 08:00-12:00.

In the year 2021, there was no carbon monoxide measurement for this year. Therefore there is no information and sulfur dioxide is found at the highest value of about 0.5 microns during 12:00-16:00 and the lowest value is 0.3 microns during 08:00-12:00.

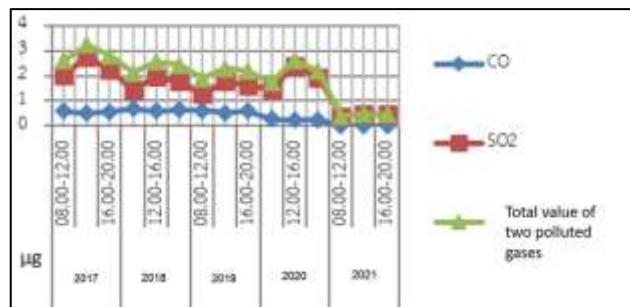


Fig. 9: Analytical graphs of the two polluted gases

## 4 Conclusion and Discussion

From the study of pollution caused by automobiles, a case study of Mueang Chon Buri District and Sriracha District, Chon Buri Province, the results can be concluded as follows.

1) **The study of factors causing air pollution caused by automobiles in Mueang Chon Buri and Sriracha Districts, Chon Buri Province** Sriracha District has an area of approximately 623.689 square kilometers and Mueang Chon Buri District has an area of approximately 255.675 square kilometers. The total area of both districts is approximately 879.364 square kilometers. Based on the distribution of the two gases, carbon monoxide, and sulfur dioxide Gas distribution, indicates that they were found in Sriracha District more than in Mueang Chon Buri District. This is because Mueang Chon Buri District has only one weather station, Ban Suan Subdistrict, Mueang Chon Buri District, Chon Buri Province, and Sriracha District with higher gas distribution values. There are 2 weather monitoring stations: ThungSukla Subdistrict, Sriracha District, Chon Buri Province, and Bowin Subdistrict, Sriracha District, Chon Buri Province.

2) **The results of the study of areas at risk of air pollution caused by automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province** According to the data for the year 2017-2021 and the results of the analysis of air pollution risky areas both in Sriracha District and Mueang Chon Buri District, the risky places include 80 traffic lights in Sriracha District, consisting of 13 parking lots, 90 garages, 281 industrial factories, 156 main roads, and 5,866 sub-roads, including Bang Saen Road, Sai 2 Road. down to Bangsaen Beach Lower Bangsaen Road, Sukhumvit Road, Highway No. 7, National Highway No. 3, Bangsaen Lang Road, National Highway No. 3466, National Highway No. 3134, Bangsaen-Ang Sila Road, Saensuk Road, National Highway No. 3129, National Highway No. 3241, National Highway No. 3138, National Highway No. 3144, Sukprayoon

Road, Akniwat Road, National Highway No. 315, National Highway No. 331, National Highway No. 344 and Highway number 34. The sources of air pollution mentioned above are among the major causes that affect the daily life of people in the community.

### **3) The results of the study on the effects of air pollution caused by automobiles in Sriracha District and Mueang Chon Buri District, Chon Buri Province**

From the analysis of 400 questionnaires, it was found that most people are affected by pollution that causes health problems more than the environmental impact on health and is found at a high level followed by moderately affected, most affected, slightly affected, and no affected at all, respectively.

#### **4.1 Discussion**

The study of factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province using the Geographic Information System (GIS), shows that Sriracha District has an area of approximately 623.689 square kilometers and Mueang Chon Buri District has an area of approximately 255.675 square kilometers. As for the area of both districts, the accumulation of both areas is approximately 879.364 square kilometers in which the distributions of carbon monoxide (CO) and sulfur dioxide (SO<sub>2</sub>) are analyzed using interpolation with IDW principles based on air quality analysis principles. When considering the distribution of the two gases, it indicates that the distribution found in Sriracha District is greater than in Mueang Chon Buri District because Mueang Chon Buri District is small in terms of area compared to Sriracha District. In addition, there is less use of industrial lands, and community activities that cause pollution are also less in Mueang Chon Buri District. In the meanwhile, Mueang Chon Buri District has only one air quality monitoring station, which is different from Sriracha District having many heavy and light industrial plants spread out with a high working population, and traffic and vehicles are used to travel at a higher rate than Mueang Chon Buri District. These findings are consistent with the research of [15], applying Geoinformatics Application on Air Quality Assessment in Bangkok to investigate the diffusion concentration of air pollutants. There are 6 types of air pollutants found in diffusion concentrations above all air quality standards: dust smaller than 10 microns (PM<sub>10</sub>), nitrogen dioxide (NO<sub>2</sub>), ozone (O<sub>3</sub>), dust smaller

than 2.5 microns (PM<sub>2.5</sub>), and sulfur gas, Dioxide (SO<sub>2</sub>) and carbon monoxide (CO).

Based on the analysis of risky areas for air pollution caused by cars from data sources of 2017-2021, the risky areas for pollution both in Mueang Chon Buri District and Sriracha District include the intersection of traffic lights in both districts, a total of 80 intersections, 138 parking lots, 90 garages, 281 industrial plants, 156 main roads, and 5,866 sub-roads. The findings mentioned reflecting the prosperity of the industry where the transportation routes are expanded in parallel with industrial plants as well as lifestyle activities of people in the community that result in high air pollution. Meanwhile, the facts reflect the laxity in the implementation of air pollution prevention measures by the government and private sectors consistent with the study carried out by [16], indicating that stakeholders still lack participation in problem-solving, especially in the government sectors. This research recommends a campaign to raise awareness among all groups of people about the problem of pollution. And the government should play a major role in solving problems with people in the community. For management guidelines, it is suggested that entrepreneurs and the middle class are willing to cooperate and want to participate in solving problems by helping to look after the problem, fixing the traffic system, reduction of dust from the construction of various projects, coordinating construction plans, public transportation system, controlling the quantity and orderliness of the four-wheeled vehicle and creating people's consciousness to love their community more. In relation to the analysis of data from the questionnaire, it reveals that most people face health problems and environmental problems the most ( $\bar{x} = 3.55$ ), consistent with the results of the study, [17], which the main impact of air pollution problems affects public health.

#### **4.2 Suggestions**

##### ***In terms of Management***

1. Agencies at district and provincial levels should continuously monitor, analyze and create a database of air quality in the general atmosphere and the release of air pollutants from their sources.
2. They should determine preventive measures and prepare an emergency plan to prevent, resolve, suppress, or alleviate emergencies or hazards from air pollution.
3. They should develop a master plan and an action plan to reduce air pollution continuously.

4. The government should promote coordination between government agencies, state enterprises, and the private sector to control and prevent air pollution, as well as support efficient and economical use of energy.

5. The government should control and reduce the use of substances that are harmful to the ozone layer.

#### ***In terms of Investment***

1. The government should promote and support the improvement or increase of fuel standards to meet international standards, including promoting the cessation of the use of toxic fuels.

2. The government should promote the creation of an efficient mass transit system as well as construct and improve roads to increase traffic surfaces.

#### ***In terms of Law***

1. The government should set and improve standards both general standards and standards of pollution sources, including setting measurement methods to meet international standards and strictly enforcing laws.

2. The government sector should determine the types of pollution sources that must be controlled for exhaust ventilation and odor emissions into the atmosphere.

3. The government should issue a policy requiring all types of vehicles and every service life to be inspected for pollution in the exhaust pipe by using a centralized inspection system and using the "Excellent Service Center" mark. "Temporarily banned" or "Absolutely do not use" for vehicles that produce pollution that exceeds the standard according to the Enhancement and Conservation of National Environment Act B.E. 1992

#### ***In terms of support***

1. Agencies at district and provincial levels should support and cooperate with private sectors, clubs or independent groups, and all media to participate in campaigns and public relations to educate, understand and realize the dangers of air pollutants and acknowledge law enforcement against Air pollutants of all types.

2. The government should support studies and research on air pollution control and disposal technologies such as biogas.

3. The government should promote the use of economic incentives to support the solution to air pollution problems.

#### **4.3 Limitations**

During the data collection process, it was found that the air quality monitoring stations did not measure lead compounds. This is another factor that can cause pollution by automobiles. Therefore, this study has been limited to incorporating such data to be co-analyzed with other relevant factors. In addition, there are few air quality measurement stations located in different areas of Thailand. The researchers use geo-informatics technology to help in gas analysis and different factors that can cause air pollution caused by cars making it easy to analyze and more clearly assess the situation of pollution.

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## Appendix

Table 1. Distribution and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province, 2017

Air Quality Index (AQI)	Air Quality	Area (Sq.km.)	Percentage	Area Boundaries		
				Sub-district	District	Province
0-10 (SO <sub>2</sub> /CO)	Very good (blue)	214.547	24.39	Khao Khan Song, Bowin, Bueng, Nong Kham	Sriracha	Chon Buri
11-20 (SO <sub>2</sub> /CO)	Good (green)	303.249	34.48	KrongTamru, Don Hua Lo, Na Pa, Bang Sai, Bang Pla Soi, Khan Khot, Ban Puek, Ban Suan, Tamarind Yong, Samnak Bok, Samet, Saensuk, Nong Khang Khok, Nong Mai Daeng, Huai Kapi, Mine, Khao Khan Song, Bang Phra, Bowin, Bueng, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
21-30 (SO <sub>2</sub> /CO)	Medium (yellow)	160.337	18.25	Ban Puek, Samet, Saensuk, Nong Khang Kok, Nong Ri, Shrimp Paste, Mine, Ang Sila, Bang Phra, Bueng, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
31-40 (SO <sub>2</sub> /CO)	Beginning to affect (Orange)	91.7424	10.43	Bang Phra, Bueng, Surasak, Nong Kham	Sriracha	Chon Buri
41-50 (SO <sub>2</sub> /CO)	Getting affected (red)	109.489	12.45	Bang Phra, Bueng, Surasak, Sriracha, Nong Kham, Laem Chabang	Sriracha	Chon Buri
<b>Total</b>		<b>879.364</b>	<b>100</b>			

Table 2. Distribution and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2018

Air Quality Index (AQI)	Air Quality	Area (Sq.km.)	Percentage	Area Boundaries		
				Sub-district	District	Province
0-10 (SO <sub>2</sub> /CO)	Very good (blue)	192.154	21.85	Khao Khan Song, Bowin, Bueng, Nong Kham	Sriracha	Chon Buri
11-20 (SO <sub>2</sub> /CO)	Good (green)	86.504	9.83	Khao Khan Song, Bang Phra, Bowin, Bueng, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
21-30 (SO <sub>2</sub> /CO)	Medium (yellow)	371.114	42.3	Khong Tamru, Madon Hua Lo, Na Pa, Bang Sai, Bang Pla Soi, Khan Khot, Ban Puk, Ban Suan, Tamarind Yong, Samnak Bok, Samet, Saensuk, Nong Khang Khok, Nong Mai Daeng, Nong Ri, ,Huai Kapi, Mine, Khao Khan Song, Bang Phra, Bowin, Bueng, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
31-40 (SO <sub>2</sub> /CO)	Beginning to affect (Orange)	114.154	12.98	Bang Saen, Mine, Bang Phra, Bueng, Surasak, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
41-50 (SO <sub>2</sub> /CO)	Getting affected (red)	115.438	13.13	Bang Phra, Bueng, Surasak, Sriracha, Nong Kham, Laem Chabang	Sriracha	Chon Buri
<b>Total</b>		<b>879.364</b>	<b>100</b>			

Table 3. Distribution and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2019

Air Quality Index (AQI)	Air Quality	Area (Sq.km.)	Percentage	Area Boundaries		
				Sub-district	District	Province
0-10 (SO <sub>2</sub> /CO)	Very good (blue)	192.608	21.9	Khao Khan Song, Bowin, Bueng, Nong Kham	Sriracha	Chon Buri
11-20 (SO <sub>2</sub> /CO)	Good (green)	85.143	9.68	Khao Khan Song, Bang Phra, Bowin, Bueng, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
21-30 (SO <sub>2</sub> /CO)	Medium (yellow)	368.732	41.93	KrongTamru, Madon Hua Lo, Na Pa, Bang Sai, Bang Pla Soi, Khan Khot, Ban Puk, Ban Suan, Tamarind Yong, Samnak Bok, Samet, San Suk, Nong Khang Khok, Nong Mai Daeng, Nong Ri. ,Huai Kapi, Mine, Khao Khan Song, Bang Phra, Bowin, Bueng, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
31-40 (SO <sub>2</sub> /CO)	Beginning to affect (Orange)	116.333	13.24	Bang Saen, Mine, Bang Phra, Bueng, Surasak, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
41-50 (SO <sub>2</sub> /CO)	Getting affected (red)	116.543	13.25	Bang Phra, Bueng, Surasak, Sriracha, Nong Kham, Laem Chabang	Sriracha	Chon Buri
<b>Total</b>		<b>879.364</b>	<b>100</b>			

Table 4. Distribution and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2020

Air Quality Index (AQI)	Air Quality	Area (Sq.km.)	Percentage	Area Boundaries		
				Sub-district	District	Province
0-10 (SO <sub>2</sub> /CO)	Very good (blue)	178.614	20.31	Khao Khan Song, Bowin, Bueng, Nong Kham	Sriracha	Chon Buri
11-20 (SO <sub>2</sub> /CO)	Good (green)	319.834	36.38	Khong Tamru, Madon Hua Lo, Na Pa, Bang Sai, Bang Pla Soi, Khan Khot, Ban Puk, Ban Suan, Tamarind Yong, Samnak Bok, Samet, San Suk, Nong Khang Khok, Nong Ri, Huai Kapi, Mines, Khao Khan Song, Bang Phra, Bowin, Bueng, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
21-30 (SO <sub>2</sub> /CO)	Medium (yellow)	167.945	19.1	Saen Suk, Nong Khang Khok, Nong Mai Daeng, Nong Ree, Huai Kapi, Mine, Ang Sila, Bang Phra, Bueng, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
31-40 (SO <sub>2</sub> /CO)	Beginning to affect (Orange)	99.844	11.35	Bang Saen, Mine, Bang Phra, Bueng, Surasak, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
41-50 (SO <sub>2</sub> /CO)	Getting affected (red)	113.122	12.86	Bang Phra, Bueng, Surasak, Sriracha, Nong Kham, Laem Chabang	Sriracha	Chon Buri
<b>Total</b>		<b>879.364</b>	<b>100</b>			

Table 5. Distribution and factors causing air pollution from automobiles in Mueang Chon Buri District and Sriracha District, Chon Buri Province of 2021

Air Quality Index (AQI)	Air Quality	Area (Sq.km.)	Percentage	Area Boundaries		
				Sub-district	District	Province
0-10 (SO <sub>2</sub> /CO)	Very good (blue)	178.614	44.11	KrongTamru, Don Hua Lo, Na Pa, Bang Sai, Bang Pla Soi, Ban Khot, Ban Puek, Ban Suan, Tamarind Yong, Samnak Bok, Samet, Nong Khang Kok, Nong Mai Daeng, Nong Ri, Huai Kapi, Mine, Khao Khan Song, Bang Phra, Bowin, Bueng, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
11-20 (SO <sub>2</sub> /CO)	Good (green)	319.834	20.46	Ban Puek, Samet, Saensuk, Nong Khang Kok, Nong Ri, Huai Kapi, Mine, Basin, Khao Khan Song, Bang Phra, Bo Win, Bueng, Nong Kham	Sriracha, Mueang Chon Buri	Chon Buri
21-30 (SO <sub>2</sub> /CO)	Medium (yellow)	167.945	14.11	Saen Suk, Mine, Bang Phra, Bueng, Nong Kham, Surasak	Sriracha, Mueang Chon Buri	Chon Buri
31-40 (SO <sub>2</sub> /CO)	Beginning to affect (Orange)	99.844	9.38	Bang Phra, Bueng, Surasak, Nong Kham	Sriracha	Chon Buri
41-50 (SO <sub>2</sub> /CO)	Getting affected (red)	113.122	11.94	Bang Phra, Bueng, Surasak, Sriracha, Nong Kham, Laem Chabang	Sriracha	Chon Buri
<b>Total</b>		<b>879.364</b>	<b>100</b>			

**Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)**

- Pichitporn Pholgerddee led the research project, involved in planning activities, supervised the work and prepared the manuscript.
- Piyanat Natchabunyawat contributed to the study of samples in laboratory and data analysis.
- Sirima Somwong helped in produce metadata, data encoding via software and interpretation.
- Thanachot Sunthonwongsakun arranged research tools, relevant materials and samples for the laboratory work.

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The authors declare that they have no conflicts of interest.

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