2019 GLOBE International Virtual Science Symposium

Discuss the influence of rainfall on the concentration of the pollutants.

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Summary

Air pollution has been being serious in Kaohsiung. We are discuss about how rainfall influence air pollutants such as CO ,SO2 ,O3 ,and NOx. We choose to analyze the data of winter because in summer, the impact of typhoons have a wide range of effects. Then we conclude that the source of air pollutants might come from traffic emission and airborne particulate.

Research motivation and purpose

Air pollution has been being serious in Kaohsiung, Taiwan ,especially for the reason of topography and the wind direction in winter when the air pollution is the most serious . In addition, traffic emission increase the pollutants concentration ,and it is considered that vehicles intensify air pollution. Just as what we learned in class: the formation of rainfall require adequate droplet and condensation nucleus, letting us think of whether rainfall, PM10 and other pollutants are related to one another. The wet deposition of pollutants can cleanse air pollutants through rainfall. We are also curious about whether rainfall will influence air pollutants such as CO,SO2 ,O3,and NOx. There are typhoons in Taiwan in summer, which will bring about a wide range of influence. In addition, Taiwan is of monsoon climate ,where the wind direction tend to be much more stable. As a result, we choose to analyze the data in winter.

Research Questions

1. Is the peak of hourly average pollutants concentration in conformity with rush hour?
2. What is the relationship between rainfall and PM10 concentration?
3. What is the influence of the rainfall on pollutants ?
4. Which pollutant affected by rainfall the most?
5. Do different durations of rainfall influence the changes of hourly pollutants concentration?

References

According to National Digital Library of Theses and Dissertations in Taiwan :

Principal component analysis results for atmospheric visibility suggest that SO2、CO、O3、PM10 and NO2 were the atmospheric airborne pollutants that had the greatest impact on visibility. During the observation periods, the major atmospheric airborne pollutant concentrations and meteorological effects were identified to establish a empirical visibility model. According to statistical analysis results, wind speed was the most important meteorological parameter influencing atmospheric visibility.

Shang-wei Yan, “Development and application of A Prediction Model for Daily Atmospheric Visibility-2009” https://hdl.handle.net/11296/ee63ny

In this study, visibility observation, aerosol sampling,and statistical analysis were conducted to investigate the influence of chemical and physical properties of suspended particles on visibility.

Jui-cheng Chang, “The Relationship of Visibility with Physical and Chemical Characteristics of Susoended Particles in Kaohsiung City-1999” https://hdl.handle.net/11296/433dwj

The aim of this work is studying seasonal variations of urban PM2.5, the effects of various measurement methods and instrumental units, different weather types, and potential source contributions on PM2.5. Moreover, the relationship of various PM2.5 speciations and sources with visibility is also investigated.

Taiwan urban PM2.5 is varied by seasons and weather patterns. Traffic emissions contributed significantly to atmospheric PM2.5, which may help the authorities in urban pollution control and assessment. Moreover, secondary inorganic ions are significant in reducing urban visibility.

Wei-yu Shih, “Varations of urban fine suspended particulate matter from various environmental factors and sources and its role on atmospheric visibility in Taiwan-2013” https://hdl.handle.net/11296/rynpq2

The relationships between high ozone events and synoptic weather patterns were investigated based on the meteorological and air-quality data at four monitoring stations in Kaohsiung city during 1997 to 2004 in this study.Siou-yi Liao, “The relationships between ozone concentration and meterrological parameters in the urban area, Kaohsiung” https://hdl.handle.net/11296/eyjf6u

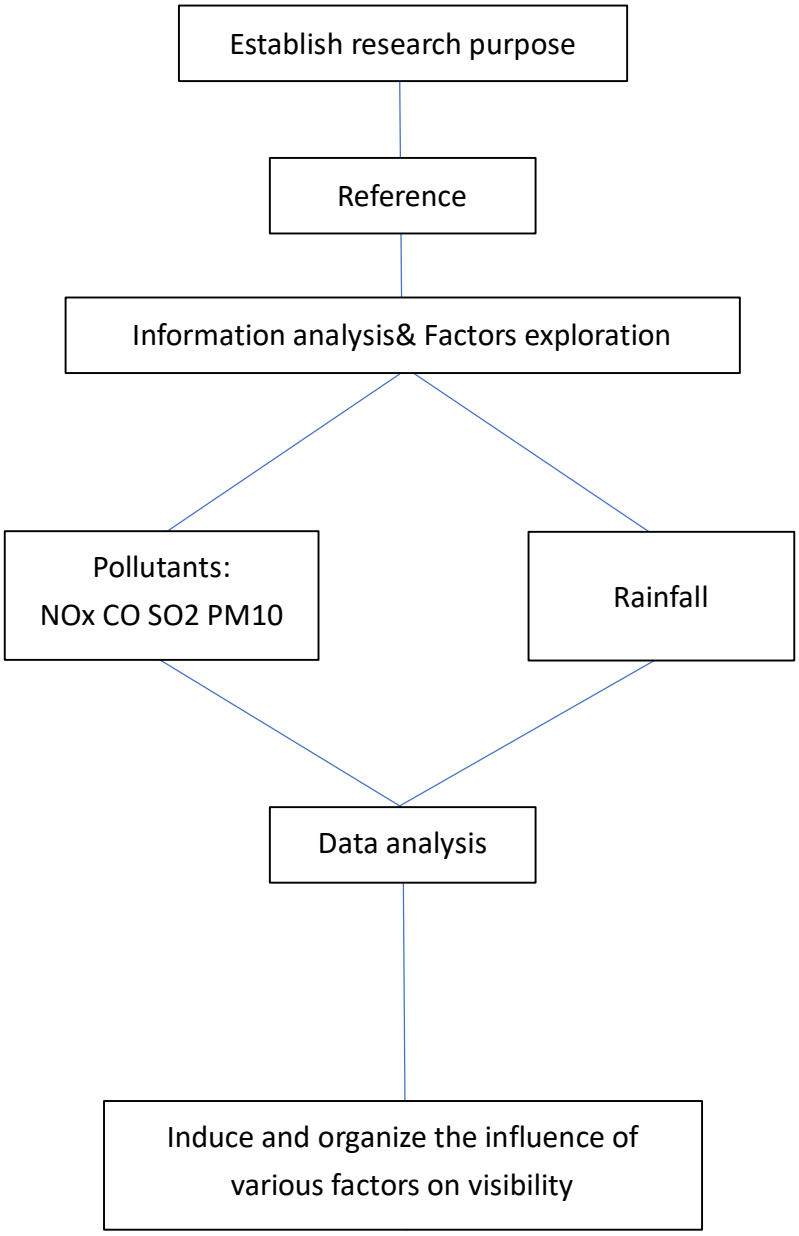
The definition of Atmospheric Temperature Inversion: If atmospheric temperatures changes are influenced by weather ,the vertical temperatures in upper air aren't in negative relationship. Rather, the temperatures in upper layer are higher than those in lower layer. This phenomenon is called “temperature inversion ”.

The properties of temperatures Inversion: temperatures Inversion layers occur in the vertical portion of the atmosphere, where it is at a steady and stable state.

Jia-jyun Jheng, “Correlation of Stratified VOCs Distribution with Atmospheric

Temperature Inversion in the Boundary Layer of Atmosphere" https://hdl.handle.net/11296/6payrk

Research Method



1. Station location and data collection:

   The data we used were collected from Environmental Protection Administration Executive Yuan R. O. C. (Taiwan) Renwu meteorological station.(Figure 1.)

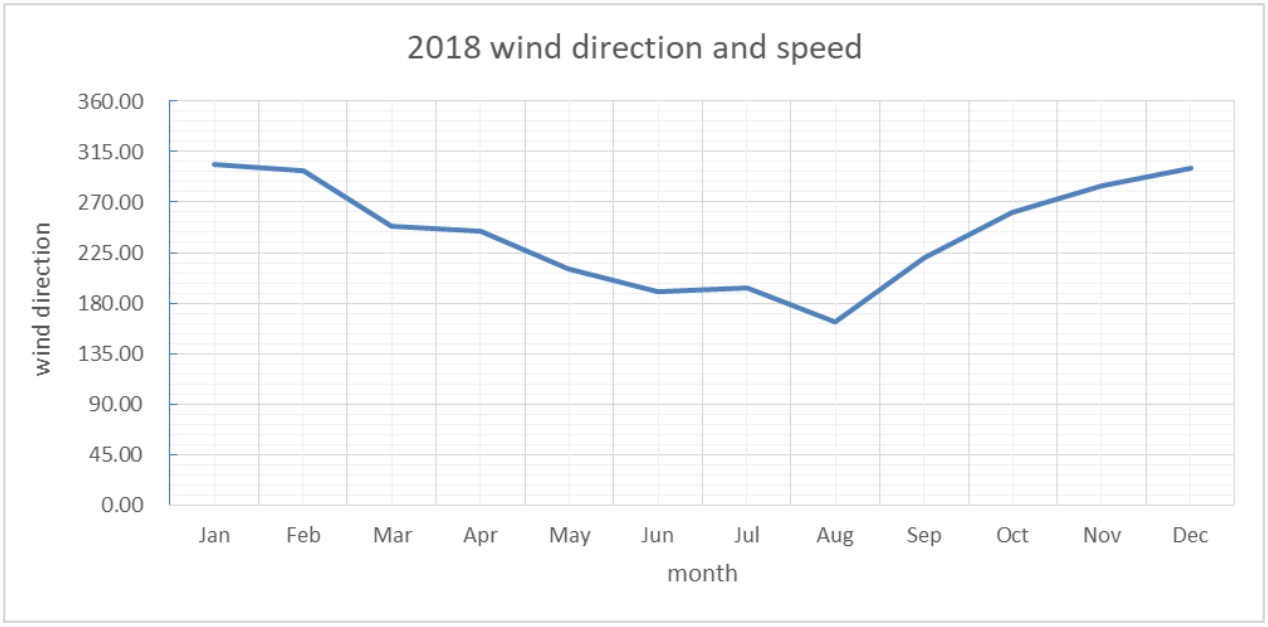
Figure 1. Environmental Protection Department Renwu Meteorological Station Location

Latitude and longitude : 120.1957°E 22.4120°N

2. information analysis

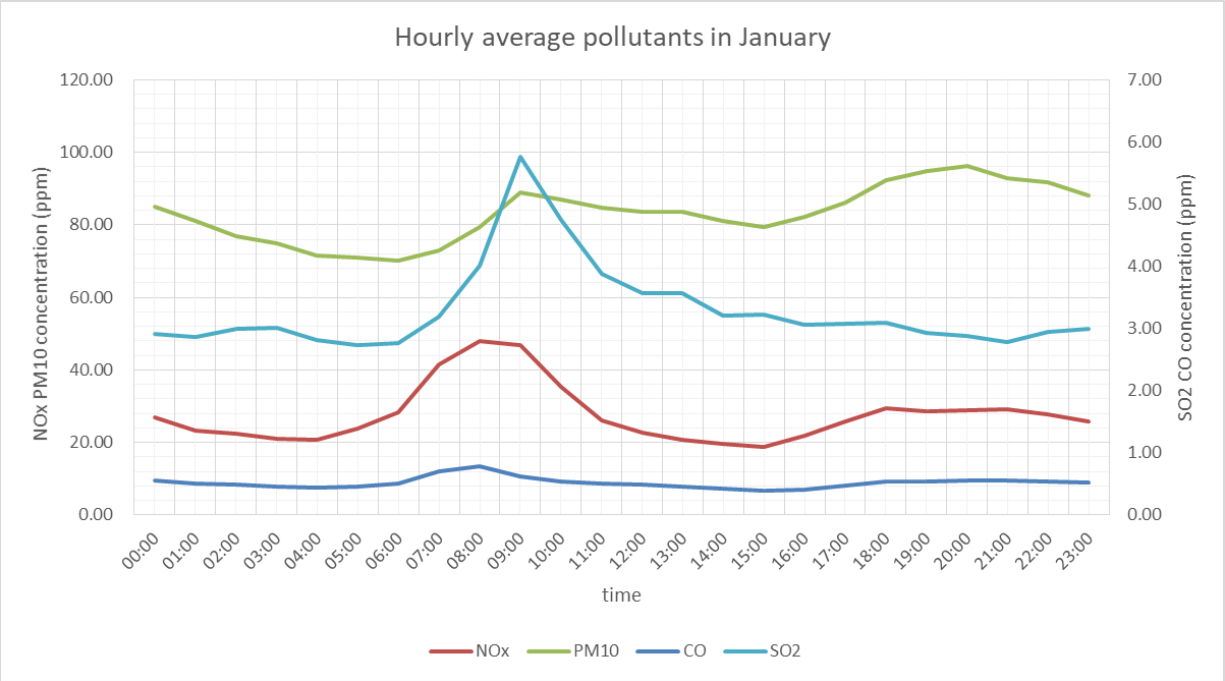
There are typhoons in Taiwan in summer, which will bring about a wide range of influence. In addition, Taiwan is of monsoon climate, where the wind direction tend to be much more stable. As a result, we choose to analyze the data in winter.

Based on the chart below, the mean wind direction was from northwest, so we took the data from 270◦to 360◦,analyzing the data in January, February, November, and December .


2018 wind direction and speed
360.00
315.00
270.00
225.00
180.00
135.00
90.00
45.00
0.00
wind direction
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month

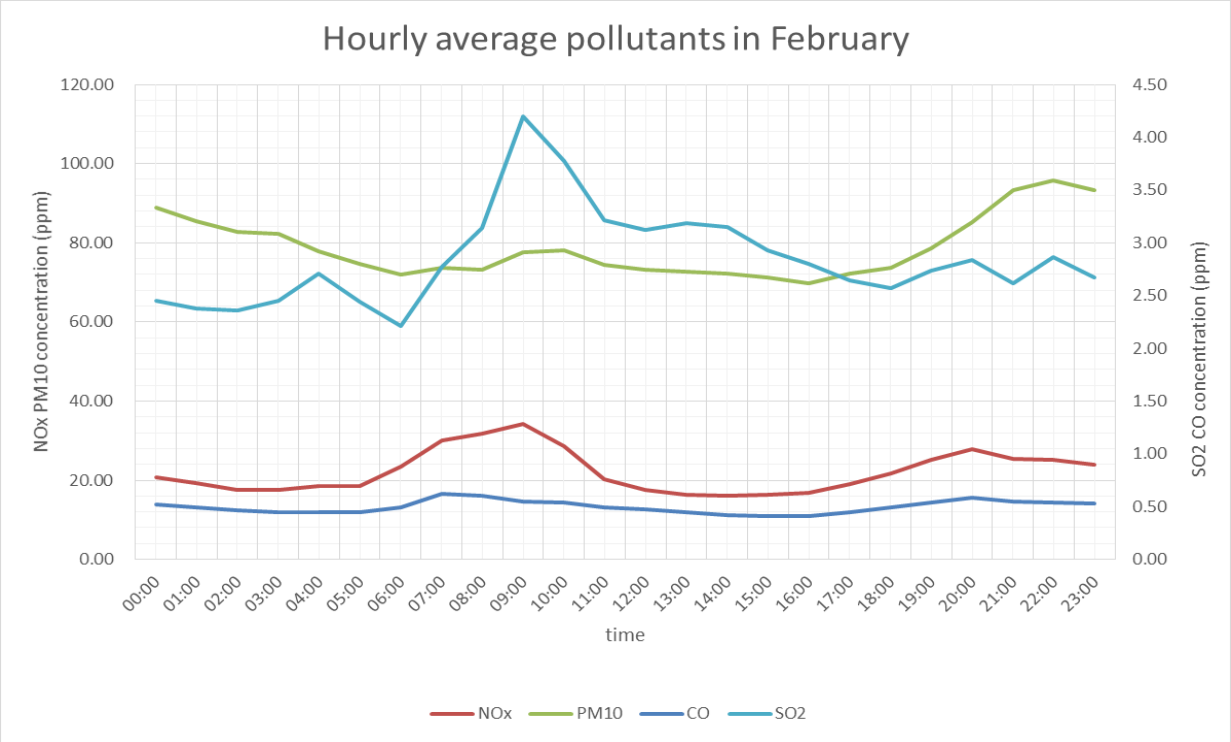
Results and conclusion

(1) The hourly changes of pollutants concentration on the days without rain in winter.



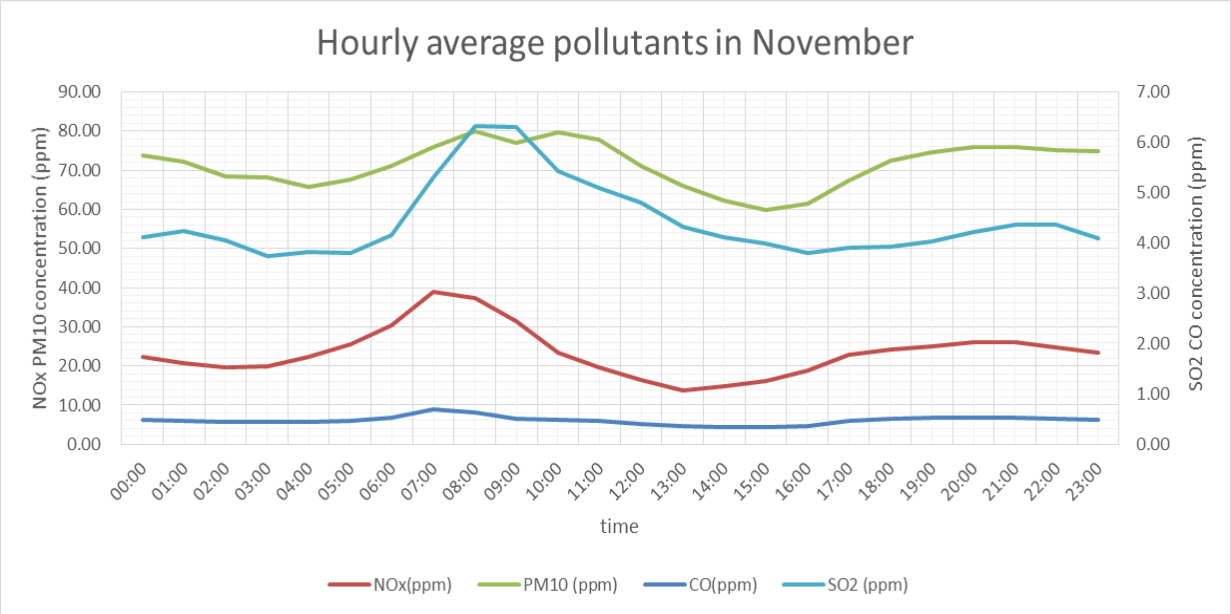
The chart shows that:

1. The peak time of SO2 concentration was around 9a.m., and it kept declining later.
2. The concentration of NOx reached to the peak around 8-9 a.m., and then continued to decline. It began to rise from 3p.m to 6 p.m. and reached another peak.
3. It was obvious that the concentration of CO arrived at a peak at about 8 a.m. ,and the concentration tended to rise at 5-6 p.m.
4. The concentration of PM10 began to rise at 7-8 a.m., reached the first peak at 9 a.m. and then continued to decline. It started to rise again in the afternoon.



The chart showed that:

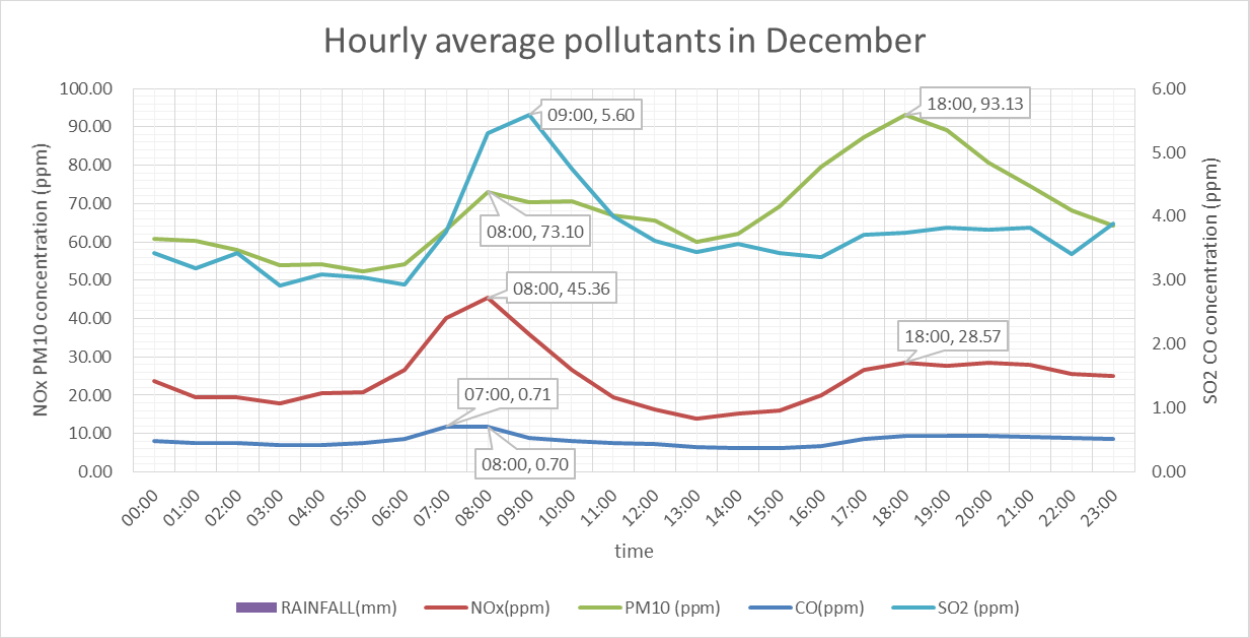
1. The concentration of SO2 reached highest peak at 9 a.m.
2. The concentration of NOx reached the peak at 8-9 a.m. and then continued to decline. It began to rise at about 4-5 p.m.
3. CO had higher concentration at 7-9 a.m., and tended to climb at 4-5p.m.
4. The concentration of PM10 tended to rise at about 4 p.m.



The chart showed that:

1. The concentration of SO2 reached highest peak at 8-9 a.m. and then continued to decline. It tended to climb at 4-5 p.m.
2. The concentration of NOx reached highest peak at 7-8 a.m. and then continued to decline. It tended to rise in the evening.

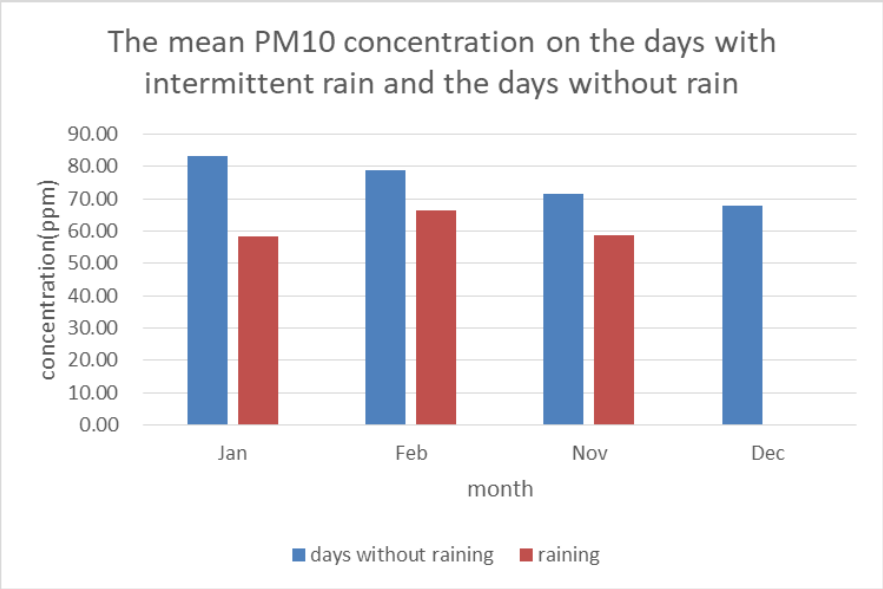
3. CO had higher concentration at about 7 a.m., and tended to rise at 4-5p.m.
4. PM10 had higher concentration at 8-10 a.m. and then continued to decline. It tended to rise at about 4 p.m.



The chart showed that:

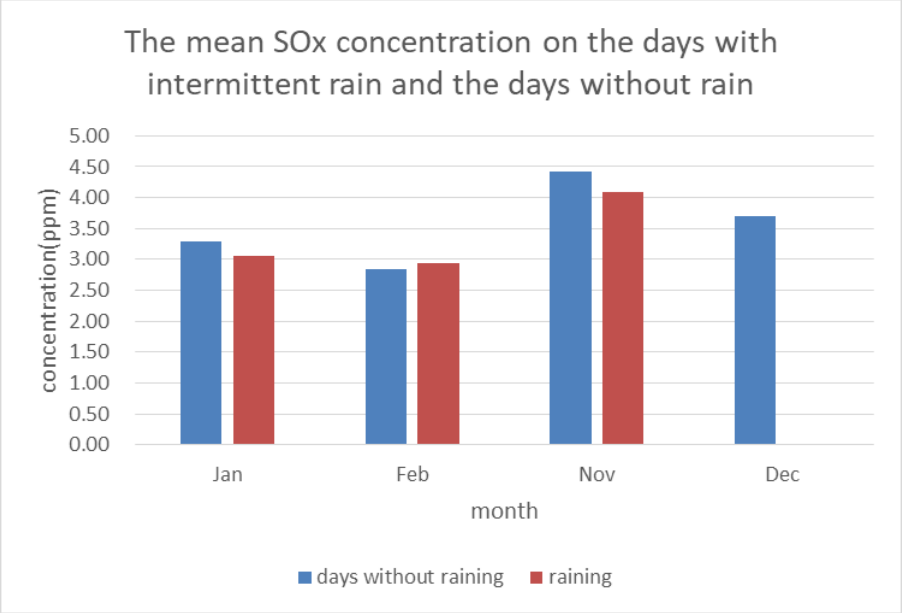
1. The concentration of SO2 reached highest peak at 8-9 a.m. and then continued to decline.
2. The concentration of NOx reached highest peak at 7-8 a.m. and then continued to decline. It tended to rise in the evening.
3. CO had higher concentration at about 7-8 a.m., and tended to rise at 4-5p.m.
4. PM10 had higher concentration at about 8 a.m. and then continued to decline. It tended to rise in the afternoon, and reached highest peak at 6 p.m.

(2) <u>The influences of rainfall on air pollutants</u>



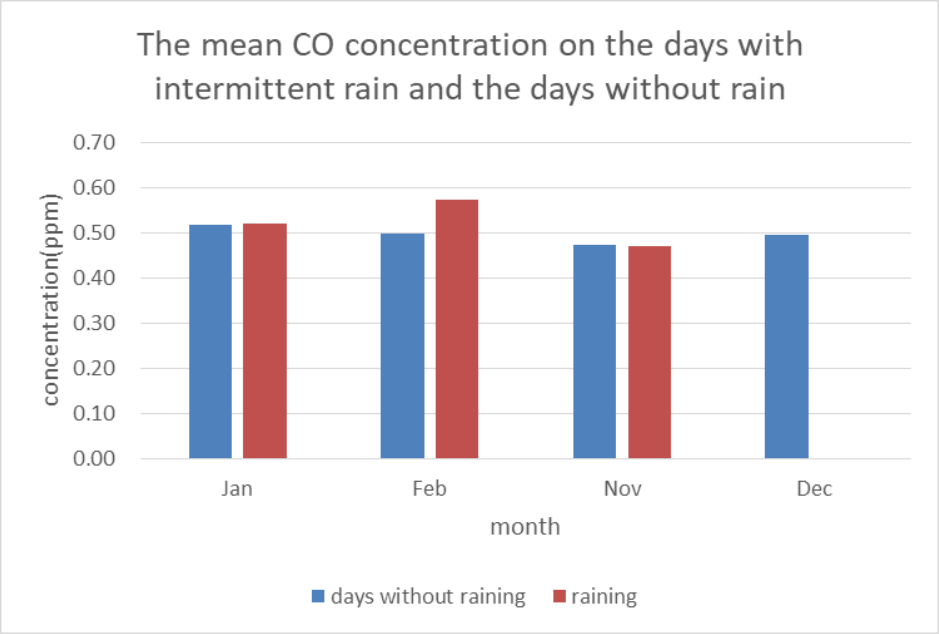
The chart showed that:

1. PM10 concentration of the days which rain are lower than the PM10 concentration of the day without raining, so we can surmise that PM10 concentration will be lower because of raining.
2. Because it didn't rain in December, there is no data to be displayed.



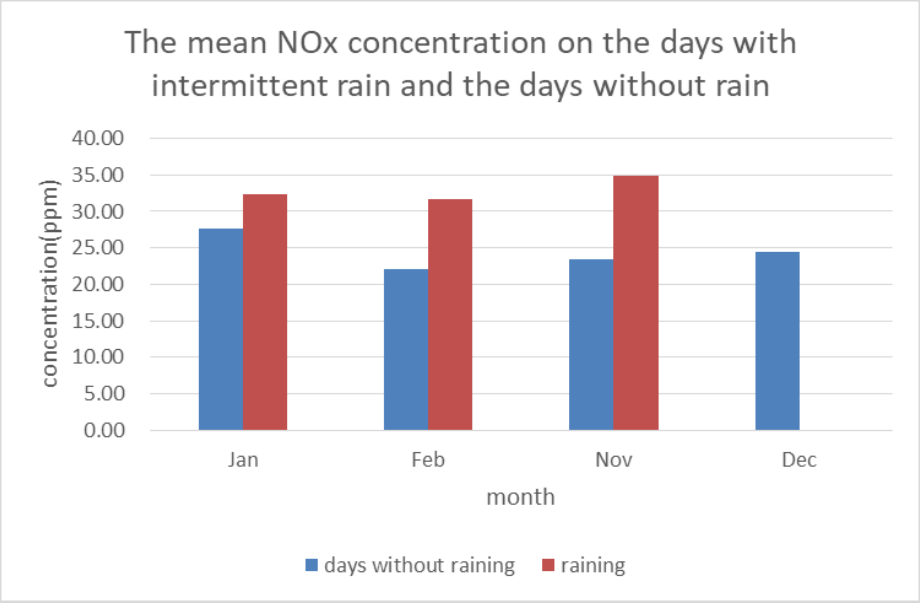
The chart showed that:

1. The SO2 concentration of the days which rain are lower than the SO2 concentration of the days without raining in January and November, so we can surmise that SO2 concentration will be lower because of raining.
2. Because it didn't rain in December, there is no data to be displayed.
3. It had exceptional data in February because there is Chinese New Year holiday.



The chart showed that:

1. There is not much change between the CO concentration of the days which rain and the CO concentration of the days without raining in January and November. We surmise that raining is difficult to impact on CO concentration.
2. Because it didn't rain in December, there is no data to be displayed.
3. Raining had no effect on the change of CO concentration. We surmise that it had been decomposed because of Photochemical Reaction, making CO concentration lower.



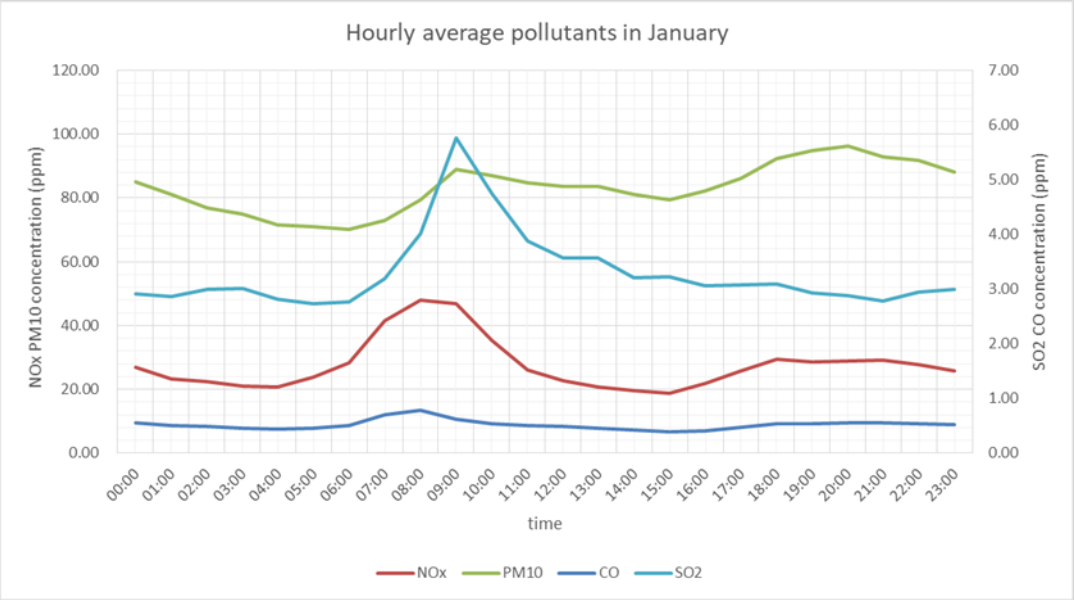
The chart showed that:

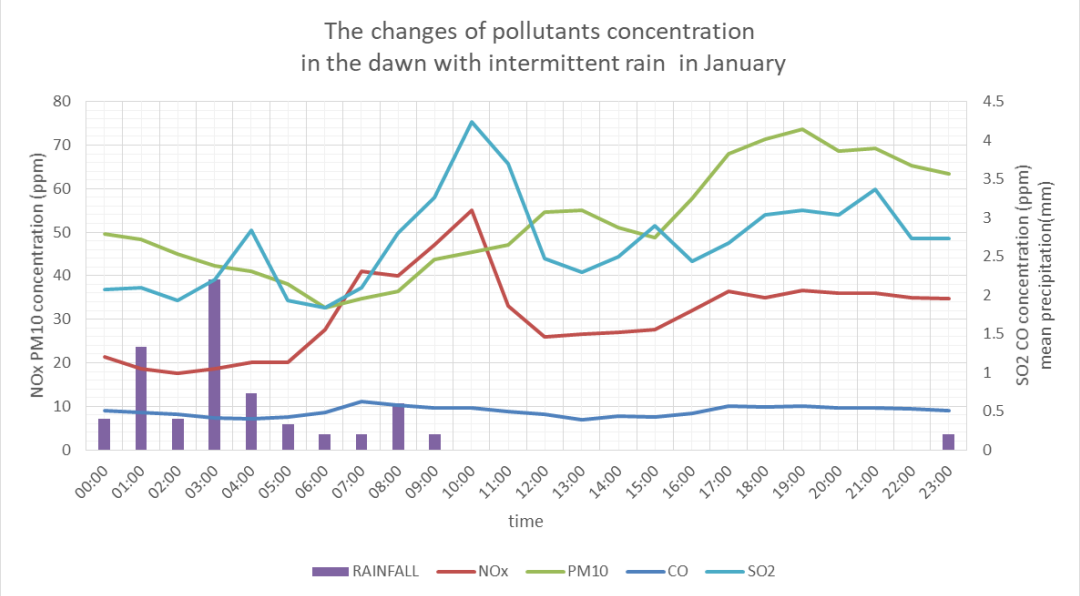
1. Raining had no effect on the change of NOx concentration, and it rose on the raining day. We surmise that it had been decomposed because of Photochemical Reaction on the days without raining, and make NOx concentration lower.

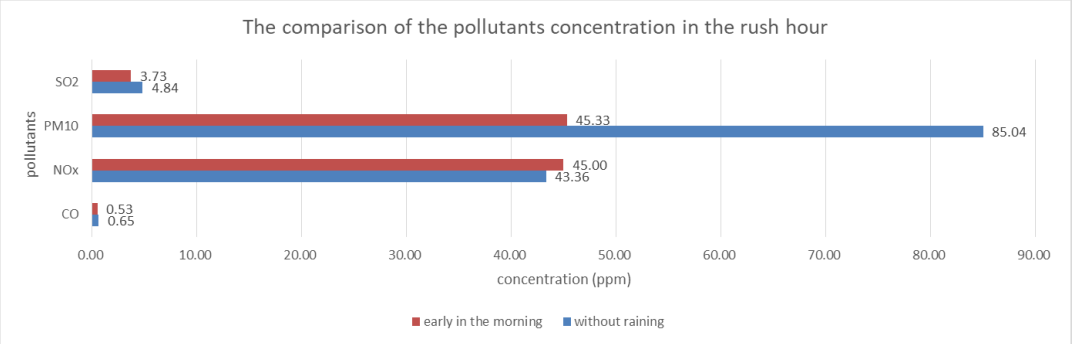
2. Because it didn't rain in December, there is no data to be displayed.

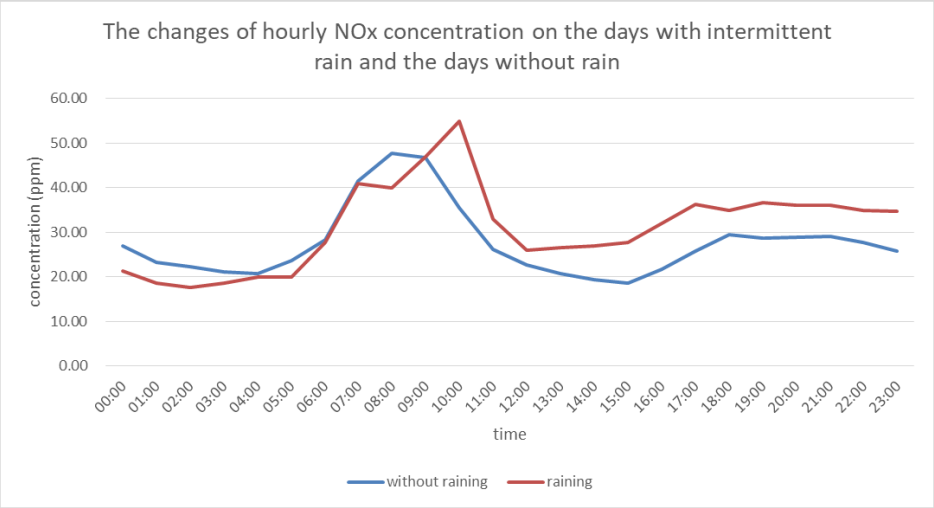
(3) <u>The influence of raining in the morning on pollutants</u>

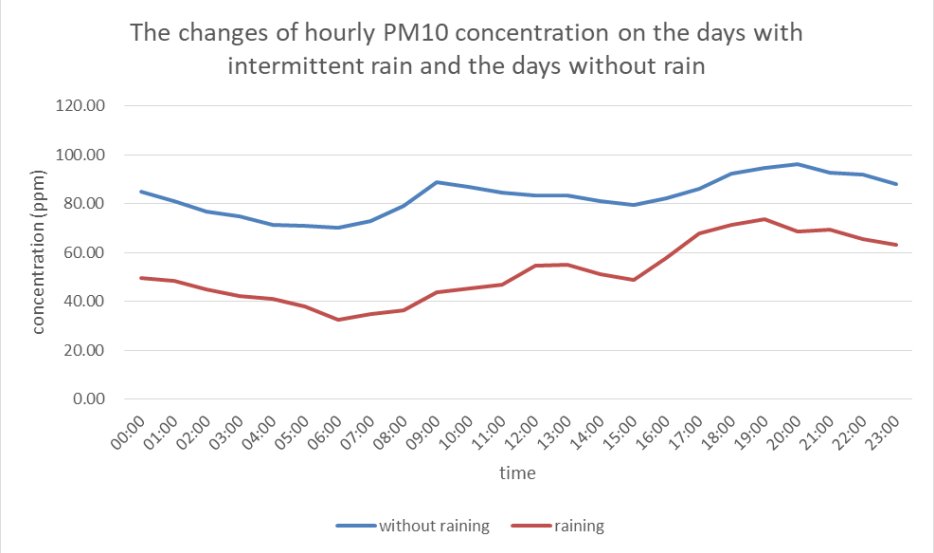
Most of thermal inversion happened on the winter morning, making the pollutants unable to spread, and add greatly to air pollution. But we found that raining influences on the change of pollutants concentration, so on the day that rains in the early morning, the air pollution will be lower and improve the air pollution cause by thermal inversion.

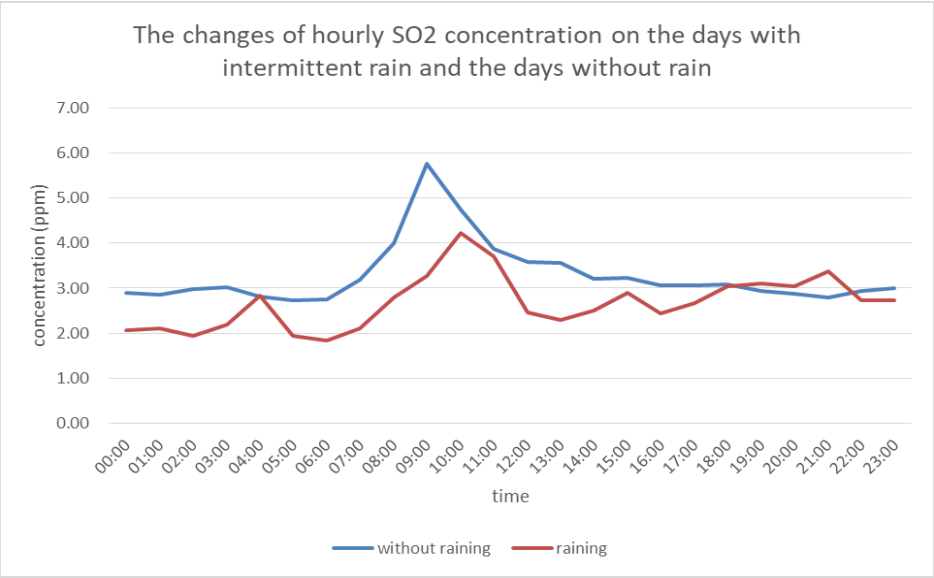


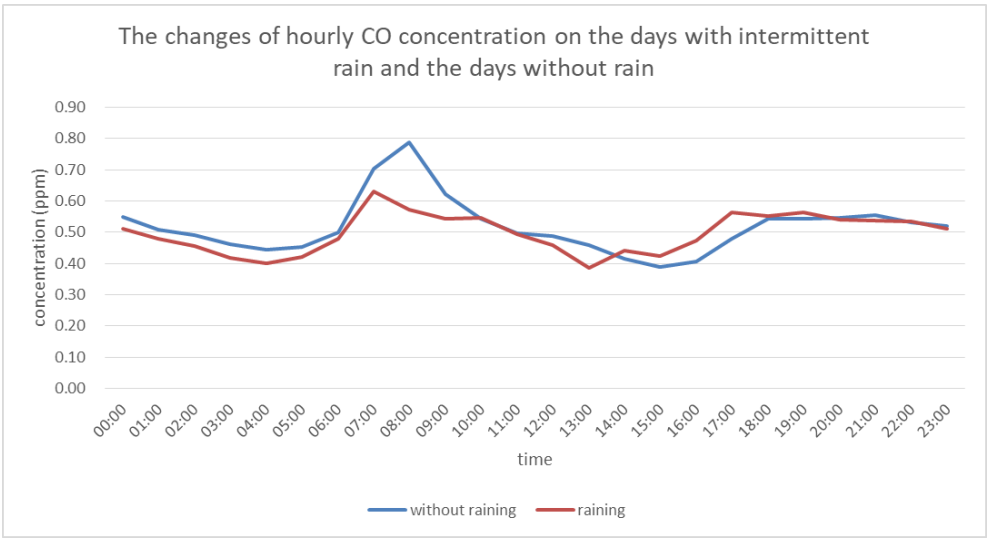



The comparison of the pollutants concentration in the rush hour
SO2
PM10
NOx
CO
pollutants
3.73
4.84
45.33
85.04
45.00
43.36
0.53
0.65
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
concentration (ppm)
early in the morning
without raining


The changes of hourly NOx concentration on the days with intermittent rain and the days without rain
60.00
50.00
40.00
30.00
20.00
10.00
0.00
concentration (ppm)
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
time
without raining
raining


The changes of hourly PM10 concentration on the days with intermittent rain and the days without rain
120.00
100.00
80.00
60.00
40.00
20.00
0.00
concentration (ppm)
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
time
without raining
raining





These chart showed that:

1. If it rains in the morning, the peak of SO2 concentration will be pushed back from 9 a.m. to about 10 a.m. The whole concentration will decrease apparently.
2. If it rains in the morning, the peak of NOx will be pushed back from 9 a.m. to about 10 a.m.
3. If it rains in the morning, the upward trend of PM10 concentration will become slower, and the first peak will be pushed back to noon. The whole concentration will decrease apparently.
4. If it rains in the morning ,CO concentration will be lower. The concentration of the days without raining will be lower than the concentration of the days which rain because of the rain.

Conclusion and Suggestions

(1) The hourly changes of pollutants concentration on the days without rain in winter

1. The peak time of SO2 concentration was around 8-9a.m.,and the concentration of SO2 rose at 4-5 p.m., whose tendency matched with rush hour. Thus, we infer that SO2 concentration change is associated with traffic emission .
2. The concentration of NOx reached to the peak around 8 a.m. ,and rose to the second peak at 4-5 p.m., whose tendency matched with rush hour. Thus, we infer that NOx concentration change is associated with traffic emission .
3. The peak time of PM10 concentration tended to be the rush hour in the morning and afternoon.
4. The concentration of CO tended to rise at 8 a.m. and 5 p.m.
5. According to the chart of hourly air pollutants concentration changes, we infer that the source of air pollutants might come from traffic emission and airborne particulate.
6. There were more people and vehicles in the rush hour ,and we infer that it may lead to higher concentration of air pollutants.

(2) The influences of rainfall on air pollutants

1. PM10 concentration on the days with intermittent rain is lower than on the days without rain. We can infer that rainfall led to air pollutants decreasing.
2. The SO2 concentration after rainfall was lower than without it .Thus, we infer that the concentration of SO2 decreased owing to rainfall .
3. The changes of CO concentration on the days with intermittent rain and the days wi*thout rain* were quite similar .We suggest that Photochemical Reaction led to CO decomposition, which make the concentration lower.
4. Raining had no effect on the change of NOx concentration, and it rose on the raining day. We surmise that it had been decomposed because of Photochemical Reaction on the days without raining, and make NOx concentration lower.

(3) The influence of raining in the morning on pollutants

1. If it rains in the morning, the peak of NOx will be pushed back from 9 a.m. to about 10 a.m. Yet, the concentration won't drop because of rainfall.
2. If it rains in the morning, the upward trend of PM10 concentration will become slower, and the first peak will be pushed back to noon. The whole concentration will decrease apparently.

3. If it rained in the early morning, the peak time of SO2 concentration delayed from around 9 a.m. to 10 a.m. The concentration decreased obviously because of rainfall .
4. We found that rainfall would influence the tendency of air pollutants concentration .Consequently, the air pollution caused by thermal inversion on the days with rainfall in the early morning could be improved.

Future Work

In the study, we found that rainfall affects the change of pollutants, so we look forward to improving our living environment with these characteristic. Therefore, we hope we can collect more data about rainfall and concentration of pollutants in the future in order to better observe the relationship between them. Besides, these pollutants has a great impact on human health, we hoping to know more about them which deserves great attention in the world nowadays.