Air quality monitoring (carbon monoxide)

1) Project background

Indoor air quality is essential to stay healthy. But every year, thousands of people die from bad air condition. Many gases are responsible like: carbon monoxide, radon, microparticles… Those gases are colorless, odorless and tasteless so we can't evaluate it without sensor. they can easily rise in a house and provoke health problem to death. That is why it is important to monitor those gases and react if there is too higher concentration of gaz.

a) Carbon monoxide

Carbon monoxide is created during a combustion or with heating system.

There are many carbon monoxide sources in a house like: stove, internal combustion engine, oven, cooker, grills, water heater…

Human body can face:

- 90 ppm for 15 mins
- 52 ppm for 30 mins
- 26 ppm for 1 hour
- 9 ppm for 8 hours

CO (in ppm)	Symptom
100	
200	Headache, tiredness, dizziness.
400	Hard headache, death after 3 hours.
800	Headache, dizziness, loss of consciousness after 45 mins, death after 2-3h
1600	Headache, dizziness death after 1h
3200	Headache, dizziness, nausea after 5 min, loss of consciousness after 30 mins
6400	Headache, dizziness, loss of consciousness after 10-15 mins
12800	Instant loss of consciousness, death after 1 to 3 mins

b) Microparticles

Microparticles are between 0.1 and 100 µm in size. It can be mineral (sand, dust) or living (pollen). Indoor microparticles comes from smoking, heating or cooking.

Microparticles are responsible for many heart and lungs diseases. Indeed, an overexposure can provoke an accumulation of microparticles in the lungs. Lungs will react by an inflammation and the patient will have shortness of breath. The fact that the lungs can't work properly induced a bad respiratory exchange. And this means that the heart needs to pump more blood.

2) Project purpose

This project is about indoor air quality. As I said before, thousand of people die because of bad air condition. Specifically, carbon monoxide and microparticles are really aggressive. That's why in this project we will measure the concentration of carbon monoxide (in ppm) and microparticles (in pcs/283ml). The system will be places in a 18m² flat for one day: 7am to 19pm. The system will record data each minute and send it to a thingspeak channel. Then the data will be processed to know the peak concentration, the exposition…

If the concentration of carbon monoxide (>250 ppm) or microparticles (>40 000 pcs/283ml) is too high, so the system will send a tweet to the customer. So, he can react.

3) Software and hardware

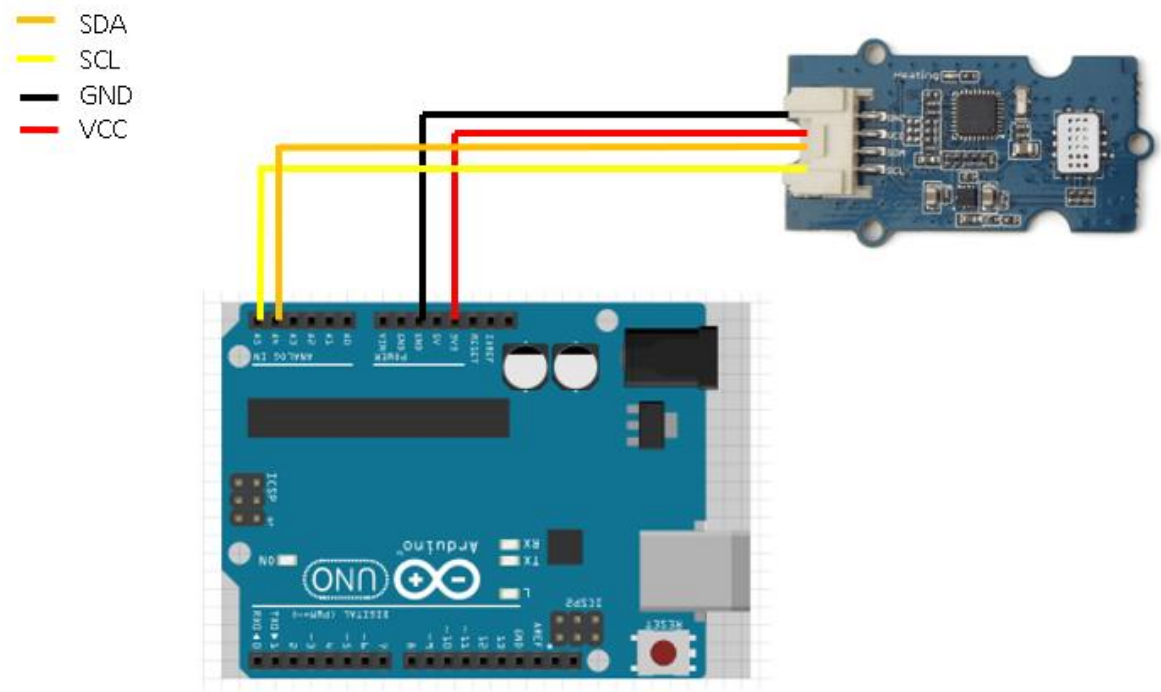
For this project I will use an Arduino that run a program for collecting data through sensors and sending data to a thingspeak channel. Data processing will be done by a python code.

In this project I will use a grove multichannel gas sensor, a grove dust sensor, a Wi-Fi module (ESP8266) and an Arduino UNO.

a) Multichannel sensor

The multichannel gas sensor will give the data for a lot of gases, but I will just focus on carbon monoxide (CO) in ppm.

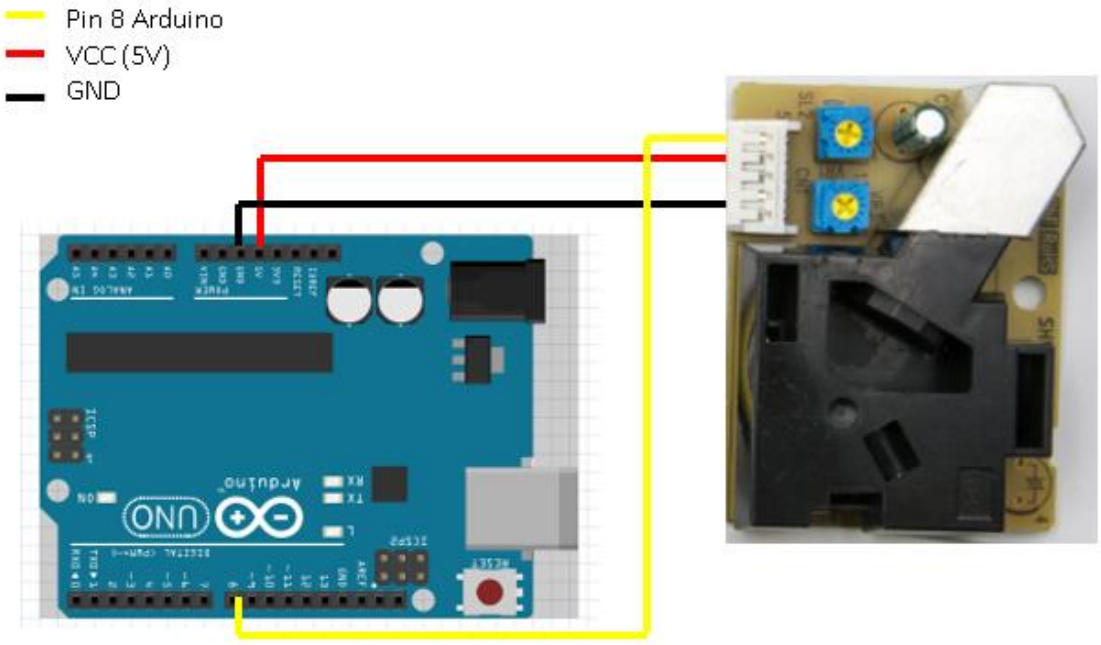
The wiring follows the diagram just below.



a) Dust sensor

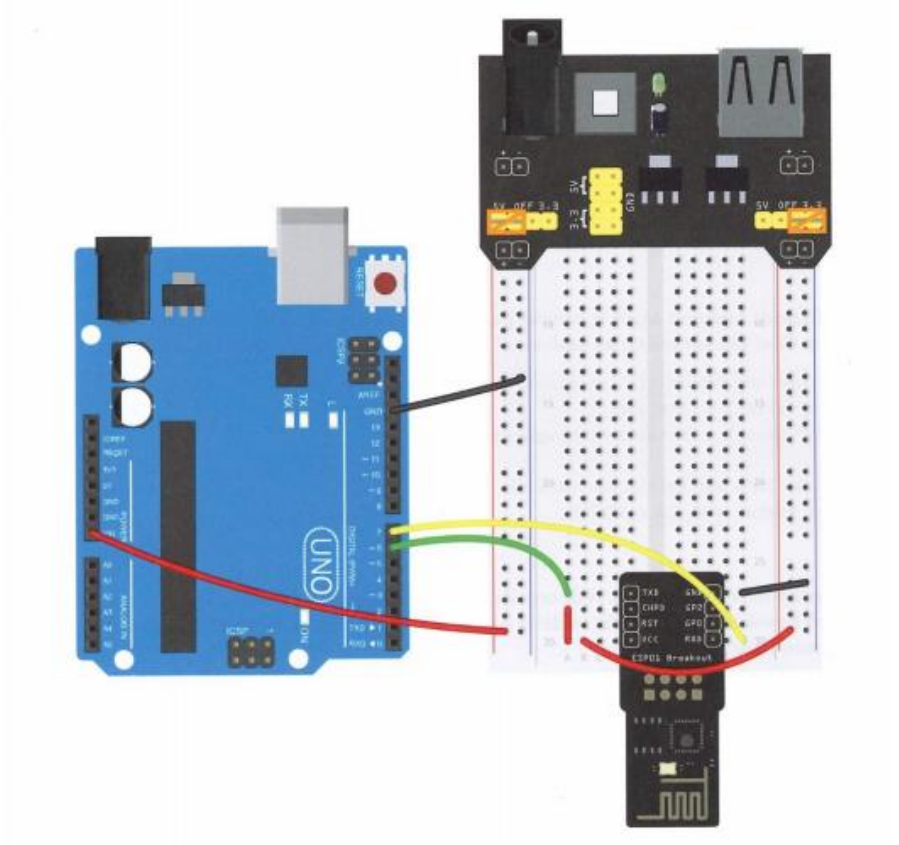
The dust sensor will give the data for microparticles in pcs/0.01f.**This system of unit is very rare and there is no equation to transform it into µg/m^3 , so the analyze will not be precise.** The Particulate Matter level (PM level) in the air is measured by counting the Low Pulse Occupancy time (LPO time) in given time unit.

http://wiki.seeedstudio.com/Grove-Dust_Sensor/

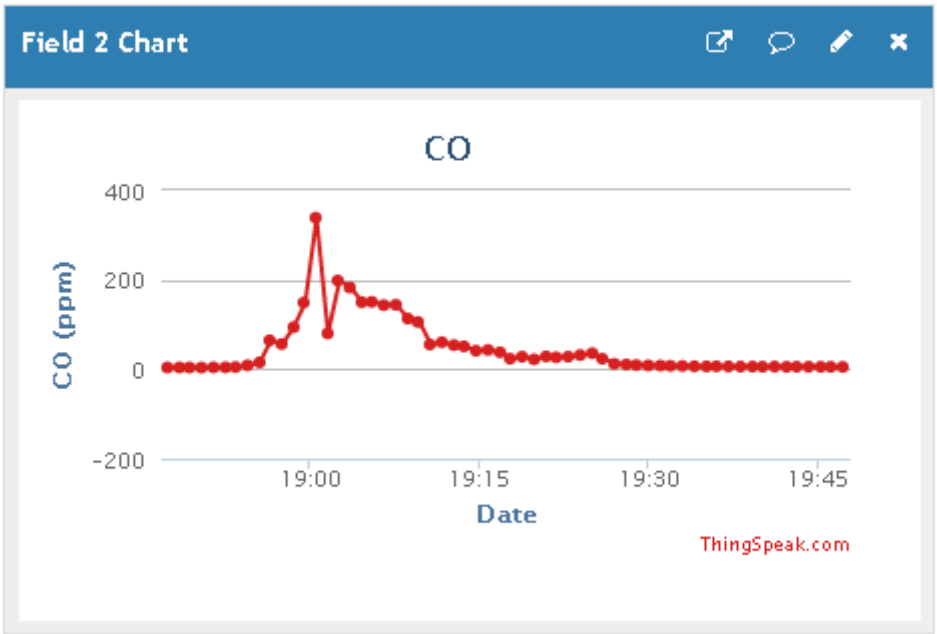


b) ESP8266 Wi-Fi module

This Wi-Fi module will send our data to a thingspeak channel. The wiring is explained below.



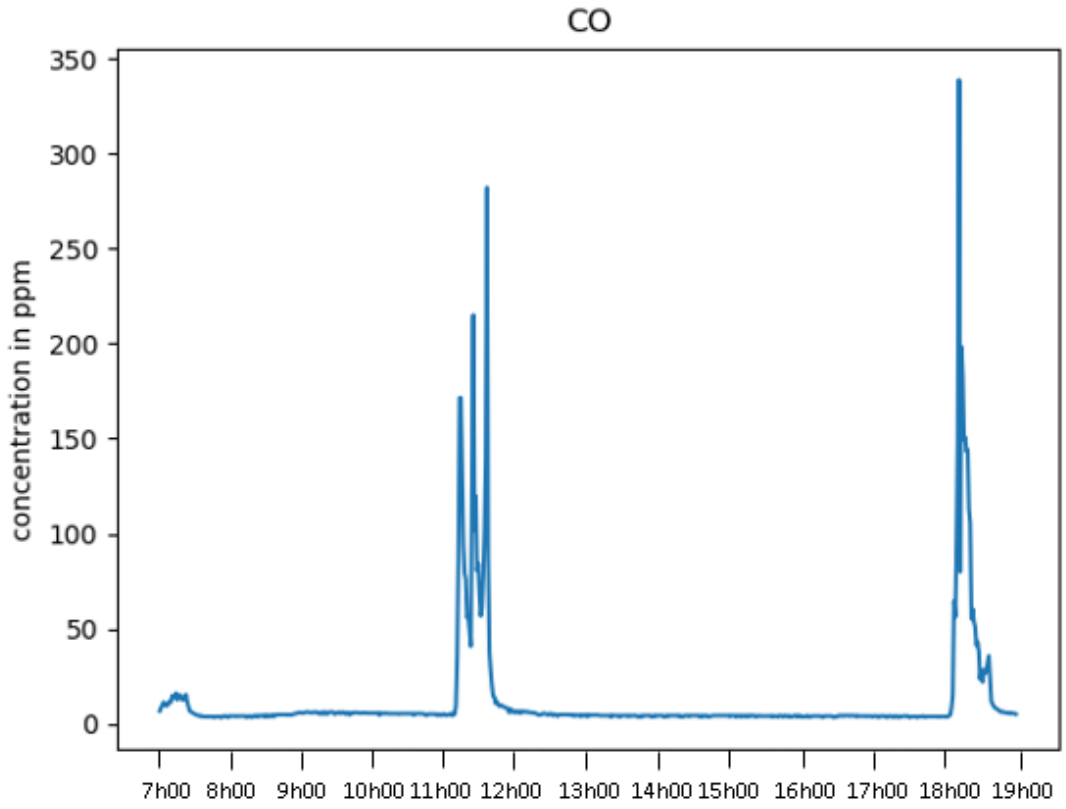
On thingspeak the data will be directly plot (like the diagram below) and we can at the end import all the data on a .csv file.



4) Measurement and data processing

a) Carbon monoxide (CO)

The system was placed in the middle of a flat of 18m². Started at 7h04 and ended at 18h47 with a data per minute



On this diagram we can see that the concentration of carbon monoxide is constant during the day except for the breakfast, lunch and dinner.

The average concentration is about 12.3 ppm. But this value is influences by the very high concentration during eating time. Otherwise when CO is constant the value is about 5-6 ppm.

```
The CO average is 12.3 ppm between 2018-10-28 07:04:00 UTC and 2018-10-28 18:47:15 UTC
```

The peak value is 338.660 ppm at 18:00.

```
The maximum peak for CO is 338.660 ppm at : 2018-10-28 18:00:36 UTC
```

The carbon monoxide has increased because of the cooker and pull up the concentration to very high rate. Bigger concentration is about 250ppm to 350ppm but for only one minute. The body can face these concentrations while the exposure time is short.

From 100 ppm, the body can be affected after 15 mins of continuous exposition. For this day, there were 20 minutes of exposition to carbon monoxide but that was not continuous, so the body can eliminate it fast enough.

```
Carbon monoxide exposure time (>100ppm) : 20.0 min between 2018-10-28 07:04:00 UTC and 2018-10-28 18:47:15 UTC
```

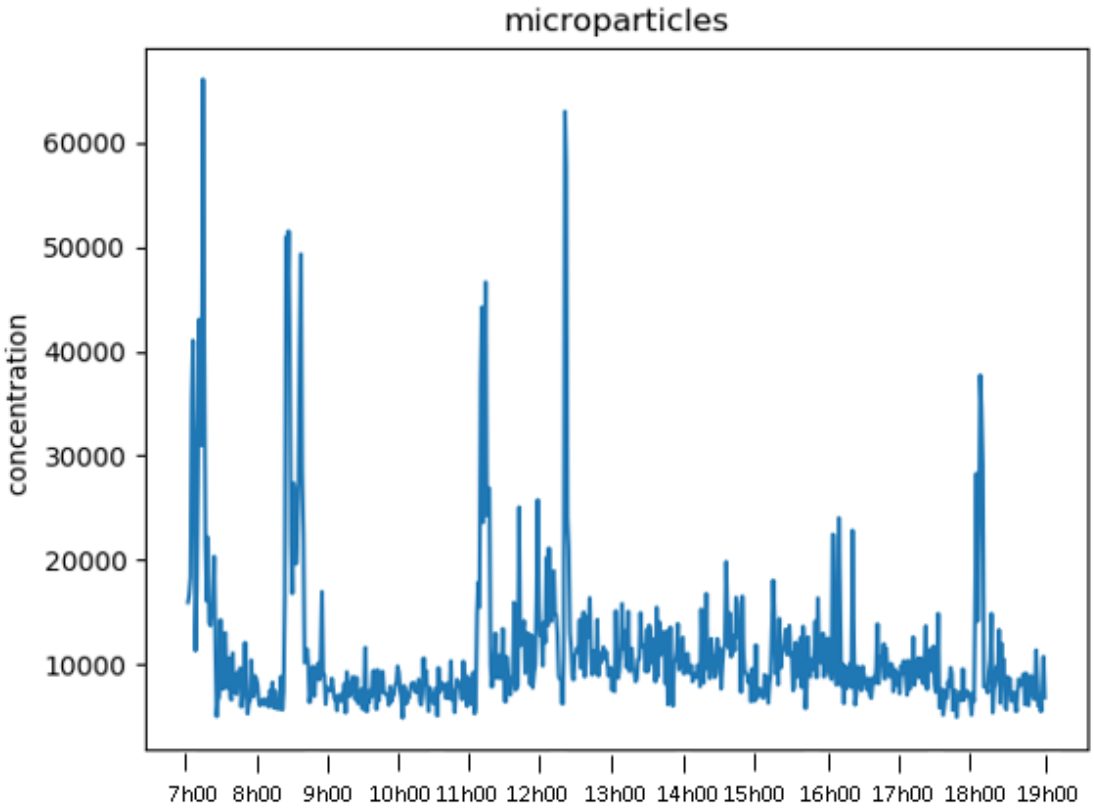
```
the ratio of high concentration of CO is :
0.02976190476190476
```

We can see that the ratio of exposition to the high concentration is quite low (almost 3% for 11hours).

For this day the body was not affected my carbon monoxide, but we can see that the concentration can rise very fast. This flat just have a cooker, no grill and no stove. So if a house have these devices, it's really important to ventilate the house to not expose the body to high concentration for too much time.

b) Microparticles

The Dust sensor was placed next to the carbon monoxide sensor for the same amount of time.



We can see of this diagram that the trend is linear except for some peak. These peaks appear at the **eating time** like carbon monoxide diagram, and 8h30, 11h, 16h too. These three was during the ventilation of the flat by open the window. The sensor rises very high when there is wind or perturbation. We see that the sensor is very sensible (to motion and wind).

The microparticles average is about: 11142.1 pcs/0.1cf(283ml)

```
The microparticle average is 11142.1 pcs/0.01f between 2018-10-28 07:04:00 UTC and 2018-10-28 18:47:15
```

The peak value is : 66077.2 pcs/0.1cf(283ml)

```
The maximum peak for micro particles is 66077.2 pcs/0.01cf at : 2018-10-28 07:16:09 UTC
```

The exposure time to high concentration of particles is about 14 minutes for 11 hours. This represent a ratio of 0.02. The rate for high concentration is fixed to 40 000 pcs/0.01cf, this rate is arbitrary, the official rate is in µg/m^3. For a good analyze this sensor can't work because there is nothing to compare to these data.

```
Particles exposure time (>40000 pcs/0.283ml) : 14.0 min between 2018-10-28 07:04:00 UTC and 2018-10-28 18:47:15 UTC
```

```
the ratio of high concentration of particles is :
0.02064896755162242
```

For this day, the rate of microparticles was quite linear except for eating day and ventilation time. So we can say that kitchen created microparticles. Same as the carbon monoxide, while the exposure time is low the body can face and eliminate microparticles.

5) Conclusion

To conclude we can say that the carbon monoxide and microparticles comes from the kitchen for this flat. The value of carbon monoxide shows that there is no danger during the day if we ventilate the flat. Indeed, the concentration peak was 338 ppm and this concentration can provoke medical issue if the exposure time is too long, not in our case (only one minute). The exposure to high concentration of carbon monoxide was about 20 minutes in total so that's alright until it is not continuous.

The concentration of microparticles rise during eating time to but fall fast between eating time. The exposure to high concentration of particles was about 14 minutes. Same as carbon monoxide it is alright until it is not continuous.

This system should be places in closed area or house with a too much combustion devices like stove, oven, heating system… Thanks to thingspeak, if there is a too higher concentration of carbon monoxide or microparticles thingspeak send a message to the host, so he can react.