Time Series Analysis with Pandas

In this project, time series data analysis with pandas is presented. The air pollution dataset of Bangkok is used for this purpose. This dataset consists of hourly update of 12 attributes between Jan 1st, 2018 to Dec 31st, 2022. The attributes consists of Datetime, pollution(pm2.5) dew point(Dewp), temperature(temp), Pressure (PRES), wind direction(cbwd), wind speed(lws), snow(ls) and rain(lr). Dataset is taken from here.

```
#import necesary libraries
import pandas as pd
import numpy as np
%matplotlib inline
```

```
#load dataset
url = 'https://raw.githubusercontent.com/Tenyyy/DES432_AIR/main/airpollution.csv'
data = pd.read_csv(url)
data.head()
```

	No	year	month	day	hour	pm2.5	DEWP	TEMP	PRES	cbwd	Iws	Is	Ir
0	1	2018	1	1	0	NaN	-21	-11.0	1021.0	NW	1.79	0	0
1	2	2018	1	1	1	NaN	-21	-12.0	1020.0	NW	4.92	0	0
2	3	2018	1	1	2	NaN	-21	-11.0	1019.0	NW	6.71	0	0
3	4	2018	1	1	3	NaN	-21	-14.0	1019.0	NW	9.84	0	0
4	5	2018	1	1	4	NaN	-20	-12.0	1018.0	NW	12.97	0	0

Data manipulation

In this section, the index are changed into datatime index, renames the columns, check the latest value, etc are perfomed in the dataset.

```
# make datatime as index
data.set_index( pd.to_datetime(data[['year','month', 'day', 'hour']]), inplace= True)
data.index.name = 'Date_time' # index name
data.head()
```

	No	year	month	day	hour	pm2.5	DEWP	TEMP	PRES	cbwd	Iws	Is	I
Date_time													
2018-01-01 00:00:00	1	2018	1	1	0	NaN	-21	-11.0	1021.0	NW	1.79	0	
2018-01-01 01:00:00	2	2018	1	1	1	NaN	-21	-12.0	1020.0	NW	4.92	0	
2018-01-													

```
# lets drop column 'No', 'year', 'month', 'day' ,'hour'
data.drop(columns=['No', 'year', 'month', 'day' ,'hour'], inplace=True)
data.head()
```

	pm2.5	DEWP	TEMP	PRES	cbwd	Iws	Is	Ir
Date_time								
2018-01-01 00:00:00	NaN	-21	-11.0	1021.0	NW	1.79	0	0
2018-01-01 01:00:00	NaN	-21	-12.0	1020.0	NW	4.92	0	0
2018-01-01 02:00:00	NaN	-21	-11.0	1019.0	NW	6.71	0	0
2018-01-01 03:00:00	NaN	-21	-14.0	1019.0	NW	9.84	0	0
2018-01-01 04:00:00	NaN	-20	-12.0	1018.0	NW	12.97	0	0

```
# rename the columns name
#data.columns = ['pollution', 'dewp', 'temp', 'press', 'wnd_dir', 'wnd_spd', 'snow', 'snow']
data.rename(columns={'pm2.5':'pollution',
                     'DEWP':'dewp',
                     'TEMP':'temp',
                     'PRES': 'press',
                     'cbwd': 'wnd_dir',
                     'Iws' :'wnd_spd',
                     'Is': 'snow',
                     'Ir' : 'rain'

                    },

                 inplace=True)
data.head()
```

	pollution	dewp	temp	press	wnd_dir	wnd_spd	snow	rain
Date_time								
2018-01-01 00:00:00	NaN	-21	-11.0	1021.0	NW	1.79	0	0
2018-01-01 01:00:00	NaN	-21	-12.0	1020.0	NW	4.92	0	0
2018-01-01 02:00:00	NaN	-21	-11.0	1019.0	NW	6.71	0	0
2018-01-01 03:00:00	NaN	-21	-14.0	1019.0	NW	9.84	0	0
2018-01-01 04:00:00	NaN	-20	-12.0	1018.0	NW	12.97	0	0

lets change the NaN into 0 and drop the first 24 rows since in pollution column since it has 24 rows with NaN (all 24 row will be zero). Analyis will be conducted mostly in this column only.

```
data.fillna(0, inplace=True)
data = data[24:] # remove  first 24 rows
data.head()
```

	pollution	dewp	temp	press	wnd_dir	wnd_spd	snow	rain
Date_time								
2018-01-02 00:00:00	129.0	-16	-4.0	1020.0	SE	1.79	0	0
2018-01-02 01:00:00	148.0	-15	-4.0	1020.0	SE	2.68	0	0
2018-01-02 02:00:00	159.0	-11	-5.0	1021.0	SE	3.57	0	0
2018-01-02 03:00:00	181.0	-7	-5.0	1022.0	SE	5.36	1	0
2018-01-02 04:00:00	138.0	-7	-5.0	1022.0	SE	6.25	2	0

```
# check null
data.isnull().sum()
```

```
pollution    0
dewp         0
temp         0
press        0
wnd_dir      0
wnd_spd      0
snow         0
rain         0
dtype: int64
```

```
#check data types
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 43800 entries, 2018-01-02 00:00:00 to 2022-12-31 23:00:00
Data columns (total 8 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   pollution  43800 non-null  float64
 1   dewp       43800 non-null  int64
```

```
     2   temp       43800 non-null  float64
     3   press      43800 non-null  float64
     4   wnd_dir    43800 non-null  object 
     5   wnd_spd    43800 non-null  float64
     6   snow       43800 non-null  int64  
     7   rain       43800 non-null  int64  
    dtypes: float64(4), int64(3), object(1)
    memory usage: 3.0+ MB
```

```
# check Latest Date Value
data['pollution'].index.max()
```

```
     Timestamp('2022-12-31 23:00:00')
```

```
# check Latest Date Index Location
data.index.argmax()
```

```
     43799
```

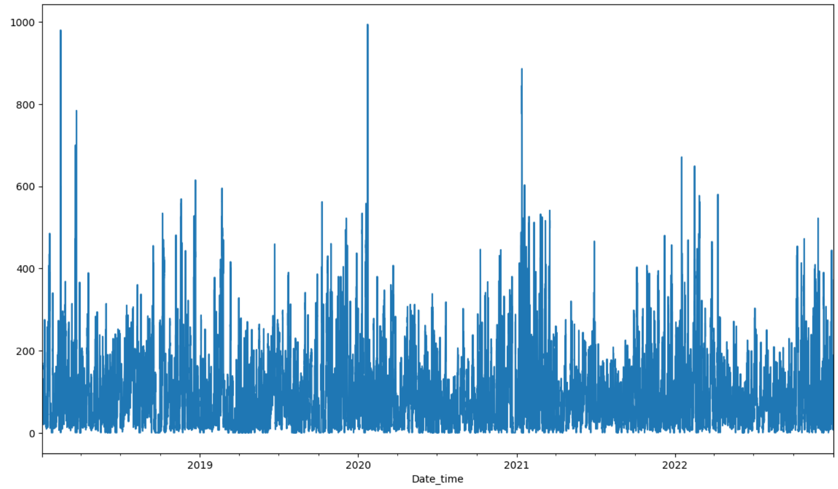
```
# check Earliest Date Value
data.index.min()
```

```
     Timestamp('2018-01-02 00:00:00')
```

```
# check Earliest Date Value
data.index.argmin()
```

```
     0
```

```
# plot air pollution
data['pollution'].plot(figsize=(14,8));
```



lets do some analysis in the dataset.

Which day was the worst day(high air pollution) over this period?

```
#data[data['pollution']==data['pollution'].max()]
data['pollution'].idxmax()
```

```
    Timestamp('2020-01-23 01:00:00')
```

Find the max air pollution days in each year and plot graph with values?

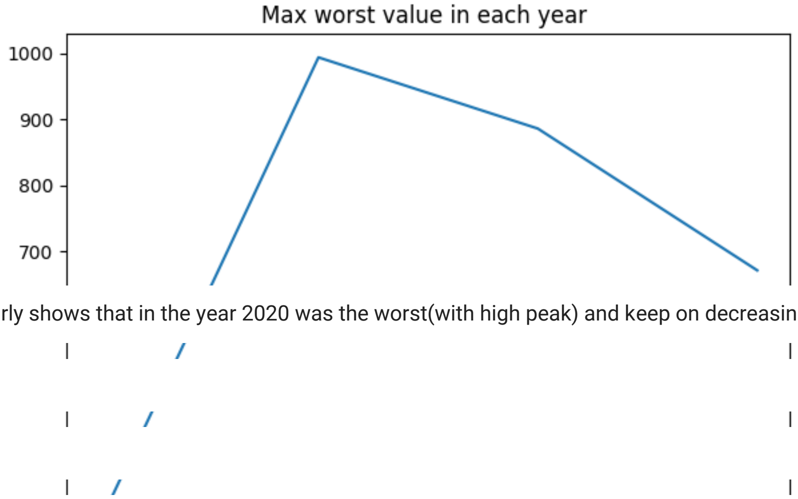
```
#stores pollution value
list_worst_days = []

#separates data based on year
data_2018 = data.loc['2018-01-01': '2018-01-31']
print('Higest air pollution day in  year 2018 is ', data_2018['pollution'].idxmax())
list_worst_days.append(data_2019['pollution'].max())

data_2019 = data.loc['2019-01-01': '2019-01-31']
print('Higest air pollution day in  year 2019 is ', data_2019['pollution'].idxmax())
list_worst_days.append(data_2019['pollution'].max())

data_2020 = data.loc['2020-01-01': '2020-01-31']
print('Higest air pollution day in  year 2020 is ', data_2020['pollution'].idxmax())
list_worst_days.append(data_2020['pollution'].max())

data_2021 = data.loc['2021-01-01': '2021-01-31']
print('Higest air pollution day in  year 2021 is ', data_2021['pollution'].idxmax())
list_worst_days.append(data_2021['pollution'].max())

data_2022 = data.loc['2022-01-01': '2022-01-31']
print('Higest air pollution day in  year 2022 is ', data_2022['pollution'].idxmax())
list_worst_days.append(data_2022['pollution'].max())
```

```
    Higest air pollution day in  year 2018 is  2018-01-19 18:00:00
    Higest air pollution day in  year 2019 is  2019-01-03 20:00:00
    Higest air pollution day in  year 2020 is  2020-01-23 01:00:00
    Higest air pollution day in  year 2021 is  2021-01-12 20:00:00
    Higest air pollution day in  year 2022 is  2022-01-16 04:00:00
```

Finding: it seems that every January month the days are wrost

lets plot these values how is the trend; is it increasing or decreasing?

```
#create series of worst values
series_worst = pd.Series(list_worst_days, index =['year_2019', 'year_2019', 'year_2020', 'year_2021' , 'year_2022'])
series_worst.plot(figsize=(7,5), title ='Max worst value in each year ');
```



It clearly shows that in the year 2020 was the worst(with high peak) and keep on decreasing.

Time Resampling

In this section, how to resample the time series data is introduced. we can do resampling based on day, month, year etc.

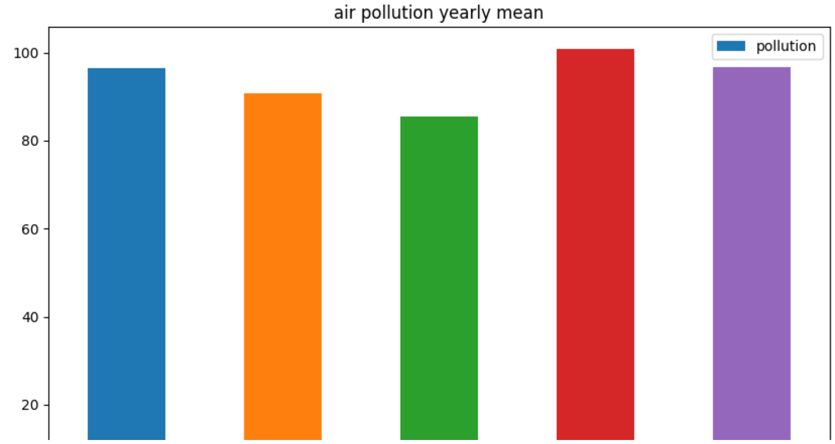
```
# Year Means
data.resample(rule='A').mean()
```

```
<ipython-input-44-54b8f4ff61ee>:2: FutureWarning: The default value of numeric_onl
  data.resample(rule='A').mean()
```

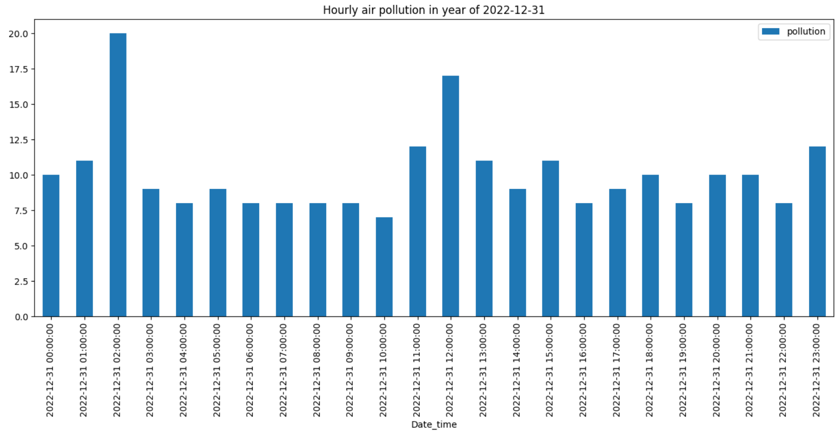
	pollution	dewp	temp	press	wnd_spd	snow	ra:
Date_time							
2018-12-31	96.363782	1.648352	11.682921	1016.328125	28.431335	0.071429	0.2686
2019-12-31	90.838014	2.134589	12.565297	1017.327283	26.232765	0.051712	0.1405
2020-12-31	85.505237	1.976890	11.967441	1016.144467	24.143322	0.071835	0.2693
2021-12-	100.760274	1.329680	12.399201	1015.799600	21.057219	0.034932	0.1600

Plot year mean

```
#yearly mean
data['pollution'].resample('A').mean().plot.bar(title='air pollution yearly mean',
                                                 legend= True,
                                                 color=['C0', 'C1', 'C2', 'C3', 'C4'],
                                                 figsize=(10,6));
```



```
# plot air pollution of 24 hours in the year 2022-12-31.
title = 'Hourly air pollution in year of 2022-12-31'
data.loc['2022-12-31': '2022-12-31'][['pollution']].plot.bar(figsize=(16,6), title=title,color='#1f77b4');
```



Time Shifting

.shift() forward

This method shifts the entire date index a given number of rows, without regard for time periods (hours, date, months & years).It returns a modified copy of the original DataFrame. And, the last given number of rows are removed.

```
data.shift(2).head()
```

	pollution	dewp	temp	press	wnd_dir	wnd_spd	snow	rain
Date_time								
2018-01-02 00:00:00	NaN	NaN	NaN	NaN	None	NaN	NaN	NaN
2018-01-02 01:00:00	NaN	NaN	NaN	NaN	None	NaN	NaN	NaN
2018-01-02 02:00:00	129.0	-16.0	-4.0	1020.0	SE	1.79	0.0	0.0
2018-01-02 03:00:00	148.0	-15.0	-4.0	1020.0	SE	2.68	0.0	0.0
2018-01-02 04:00:00	159.0	-11.0	-5.0	1021.0	SE	3.57	0.0	0.0

```
# NOTE:  last 2 piece of data that no longer has an index!
data.shift(2).tail()
```

	pollution	dewp	temp	press	wnd_dir	wnd_spd	snow	rain
Date_time								
2022-12-31 19:00:00	9.0	-22.0	-1.0	1033.0	NW	221.24	0.0	0.0
2022-12-31 20:00:00	10.0	-22.0	-2.0	1033.0	NW	226.16	0.0	0.0
2022-12-31 21:00:00	8.0	-23.0	-2.0	1034.0	NW	231.97	0.0	0.0
2022-12-31 22:00:00	10.0	-22.0	-3.0	1034.0	NW	237.78	0.0	0.0
2022-12-31 23:00:00	10.0	-22.0	-3.0	1034.0	NW	242.70	0.0	0.0

▾ .shift() backwards

```
data.shift(-1).head()
```

	pollution	dewp	temp	press	wnd_dir	wnd_spd	snow	rain
Date_time								
2018-01-02 00:00:00	148.0	-15.0	-4.0	1020.0	SE	2.68	0.0	0.0
2018-01-02 01:00:00	159.0	-11.0	-5.0	1021.0	SE	3.57	0.0	0.0
2018-01-02 02:00:00	181.0	-7.0	-5.0	1022.0	SE	5.36	1.0	0.0
2018-01-02 03:00:00	138.0	-7.0	-5.0	1022.0	SE	6.25	2.0	0.0
2018-01-02 04:00:00	109.0	-7.0	-6.0	1022.0	SE	7.14	3.0	0.0

```
data.shift(-1).tail()
```

	pollution	dewp	temp	press	wnd_dir	wnd_spd	snow	rain
Date_time								
2022-12-31 19:00:00	10.0	-22.0	-3.0	1034.0	NW	237.78	0.0	0.0
2022-12-31 20:00:00	10.0	-22.0	-3.0	1034.0	NW	242.70	0.0	0.0
2022-12-31 21:00:00	8.0	-22.0	-4.0	1034.0	NW	246.72	0.0	0.0
2022-12-31 22:00:00	12.0	-21.0	-3.0	1034.0	NW	249.85	0.0	0.0
2022-12-31 23:00:00	NaN	NaN	NaN	NaN	None	NaN	NaN	NaN

▾ Shifting based on Time Series Frequency Code

shift(forward or backward) the rows in dataframe based on the frequency code, for example, hour, day, month, year, etc.

```
# Shift everything forward one hour
data.shift(periods=2, freq='H').tail()
```

Date_time	pollution	dewp	temp	press	wnd_dir	wnd_spd	snow	rain
2022-12-31 21:00:00	8.0	-23	-2.0	1034.0	NW	231.97	0	0
2022-12-31 22:00:00	10.0	-22	-3.0	1034.0	NW	237.78	0	0
2022-12-31 23:00:00	10.0	-22	-3.0	1034.0	NW	242.70	0	0
2023-01-01 00:00:00	8.0	-22	-4.0	1034.0	NW	246.72	0	0

Rolling and Expanding

In the section, rolling and expandaing feature of pandas is introduced. **In the rolling** , the data is divided into certain rows(window size) and apply the desire function to perfom the desire task, for example window size = 2 means it calculates the function of just two previous rows, but **In the Expanding** , it takes account every rows from start to the each point in time series, for example min_period = 3 means it takes all previous rows to the current row and apply the function.

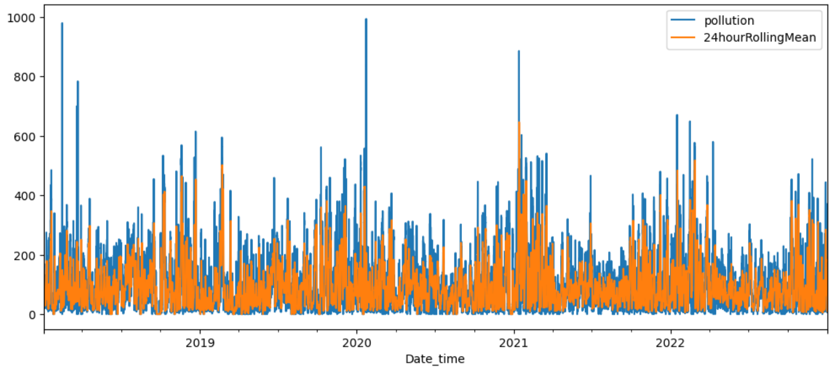
```
# 24 hour rolling mean
data.rolling(window= 24).mean().head(25)
```

```
<ipython-input-52-e6d8925017fe>:2: FutureWarning: Dropping of nuisance columns in
  data.rolling(window= 24).mean().head(25)
```

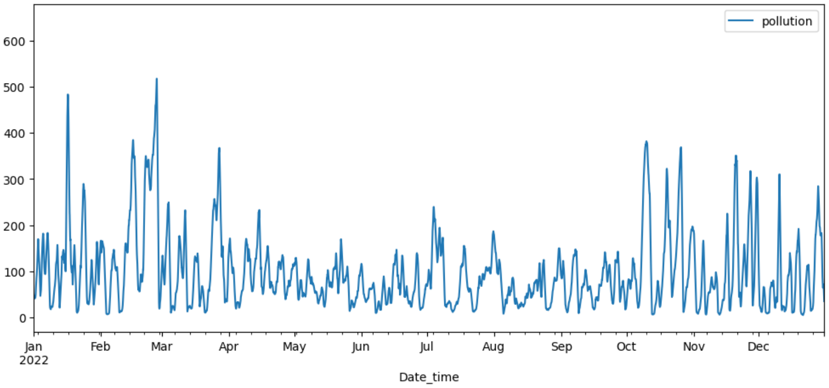
Date_time	pollution	dewp	temp	press	wnd_spd	snow	rain
2018-01-02 00:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 01:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 02:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 03:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 04:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 05:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 06:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 07:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 08:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 09:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 10:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 11:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 12:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 13:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 14:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02 15:00:00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2018-01-02							

```
#plot 24 hour rolling mean  with original data
```

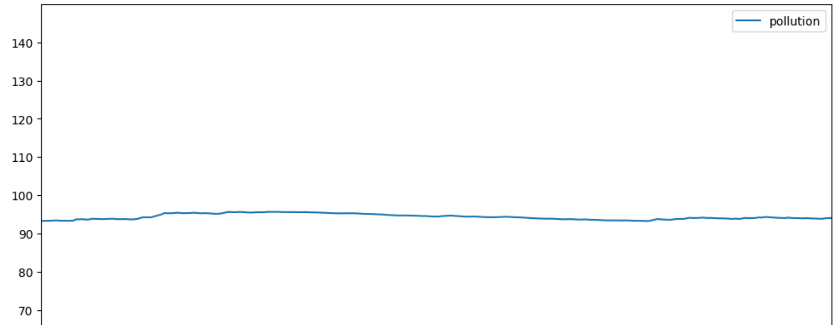
```
data['24hourRollingMean'] = data['pollution'].rolling(window=24).mean()
data[['pollution','24hourRollingMean']].plot(figsize=(12,5)).autoscale(axis='x',tight=True);
```



```
# rolling mean of 24 hours in year 2022
data[['pollution']].rolling(window = 24).mean().plot(figsize=(12,5), xlim=['2022-01-01','2022-12-31']);
```



```
#24 hours mean in year 2022 using expanding
#data[['pollution']].expanding(min_periods=24).mean().head(10)
data[['pollution']].expanding(min_periods=24).mean().plot(figsize=(12,5), xlim=['2022-01-01','2022-12-31']);
```

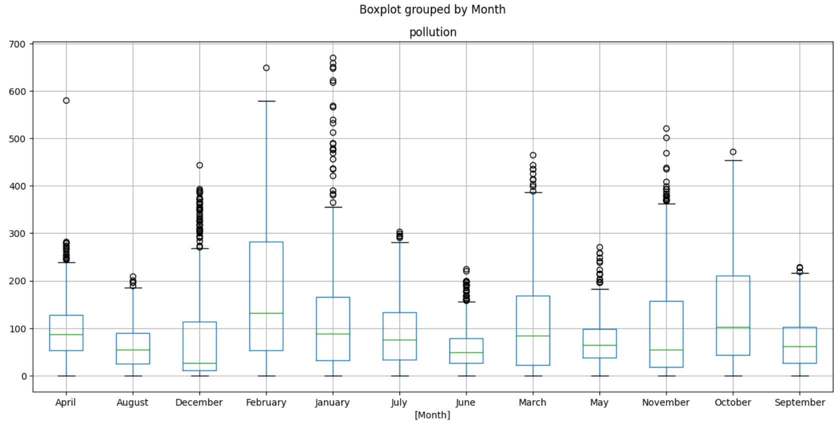


Create a BoxPlot that groups by the Month field for year 2022

```
#creates month column
data['Month']=data.index.month
data['Month']=data.index.strftime('%B')
data.head()
```

	pollution	dewp	temp	press	wnd_dir	wnd_spd	snow	rain	24hourRolli
Date_time									
2018-01-02 00:00:00	129.0	-16	-4.0	1020.0	SE	1.79	0	0	
2018-01-02 01:00:00	148.0	-15	-4.0	1020.0	SE	2.68	0	0	
2018-01-									

```
# box plot group by month in year 2022
data.loc['2022-01-01':][['pollution','Month']].boxplot(by='Month', figsize=(15,7));
```



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