Importing Libraries

In [1]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
```

Importing Datasets

In [2]:
```
df=pd.read_csv(r"E:\154\C10_air\csvs_per_year\csvs_per_year\madrid_2014.csv")
df
```

Out[2]:

	date	BEN	CO	EBE	NMHC	NO	NO_2	O_3	PM10	PM25	SO_2	TCH	TOL	
0	2014-06-01 01:00:00	NaN	0.2	NaN	NaN	3.0	10.0	NaN	NaN	NaN	3.0	NaN	NaN	28
1	2014-06-01 01:00:00	0.2	0.2	0.1	0.11	3.0	17.0	68.0	10.0	5.0	5.0	1.36	1.3	28
2	2014-06-01 01:00:00	0.3	NaN	0.1	NaN	2.0	6.0	NaN	NaN	NaN	NaN	NaN	1.1	28
3	2014-06-01 01:00:00	NaN	0.2	NaN	NaN	1.0	6.0	79.0	NaN	NaN	NaN	NaN	NaN	28
4	2014-06-01 01:00:00	NaN	NaN	NaN	NaN	1.0	6.0	75.0	NaN	NaN	4.0	NaN	NaN	28
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
210019	2014-09-01 00:00:00	NaN	0.5	NaN	NaN	20.0	84.0	29.0	NaN	NaN	NaN	NaN	NaN	28
210020	2014-09-01 00:00:00	NaN	0.3	NaN	NaN	1.0	22.0	NaN	15.0	NaN	6.0	NaN	NaN	28
210021	2014-09-01 00:00:00	NaN	NaN	NaN	NaN	1.0	13.0	70.0	NaN	NaN	NaN	NaN	NaN	28
210022	2014-09-01 00:00:00	NaN	NaN	NaN	NaN	3.0	38.0	42.0	NaN	NaN	NaN	NaN	NaN	28
210023	2014-09-01 00:00:00	NaN	NaN	NaN	NaN	1.0	26.0	65.0	11.0	NaN	NaN	NaN	NaN	28

210024 rows × 14 columns

Data Cleaning and Data Preprocessing

In [3]:
```
df=df.dropna()
```

In [4]:
```
df.columns
```

Out[4]:
```
Index(['date', 'BEN', 'CO', 'EBE', 'NMHC', 'NO', 'NO_2', 'O_3', 'PM10', 'PM2
5',
       'SO_2', 'TCH', 'TOL', 'station'],
      dtype='object')
```

In [5]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 13946 entries, 1 to 210006
Data columns (total 14 columns):
 #   Column   Non-Null Count  Dtype  
---  ------   --------------  -----  
 0   date     13946 non-null  object 
 1   BEN      13946 non-null  float64
 2   CO       13946 non-null  float64
 3   EBE      13946 non-null  float64
 4   NMHC     13946 non-null  float64
 5   NO       13946 non-null  float64
 6   NO_2     13946 non-null  float64
 7   O_3      13946 non-null  float64
 8   PM10     13946 non-null  float64
 9   PM25     13946 non-null  float64
 10  SO_2     13946 non-null  float64
 11  TCH      13946 non-null  float64
 12  TOL      13946 non-null  float64
 13  station  13946 non-null  int64  
dtypes: float64(12), int64(1), object(1)
memory usage: 1.6+ MB
```

In [6]:
```
data=df[['CO' ,'station']]
data
```

Out[6]:

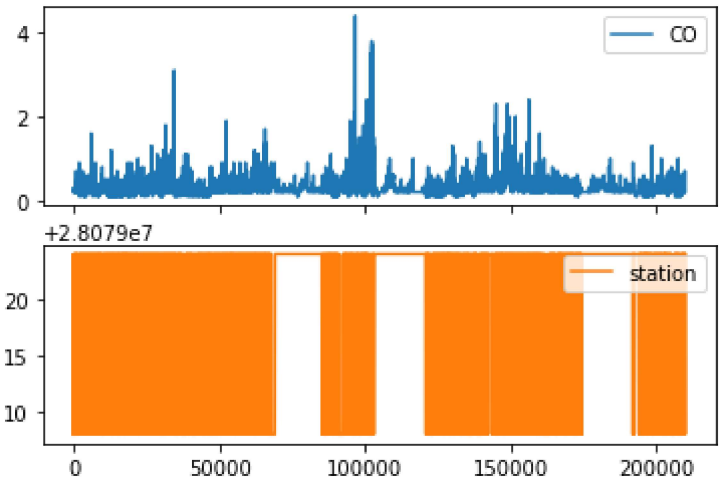
	CO	station
1	0.2	28079008
6	0.2	28079024
25	0.2	28079008
30	0.2	28079024
49	0.2	28079008
...	...	...
209958	0.2	28079024
209977	0.7	28079008
209982	0.2	28079024
210001	0.4	28079008
210006	0.2	28079024

13946 rows × 2 columns

Line chart

In [7]:
```
data.plot.line(subplots=True)
```

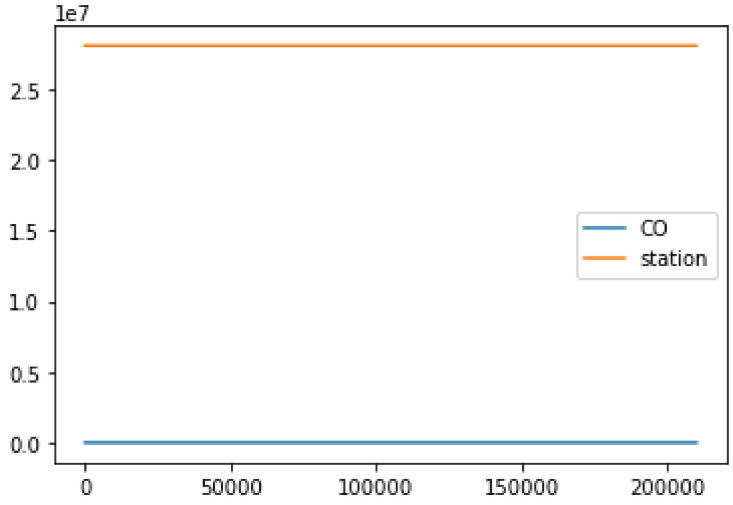
Out[7]:
```
array([<AxesSubplot:>, <AxesSubplot:>], dtype=object)
```



Line chart

In [8]:
```
data.plot.line()
```

Out[8]: <AxesSubplot:>

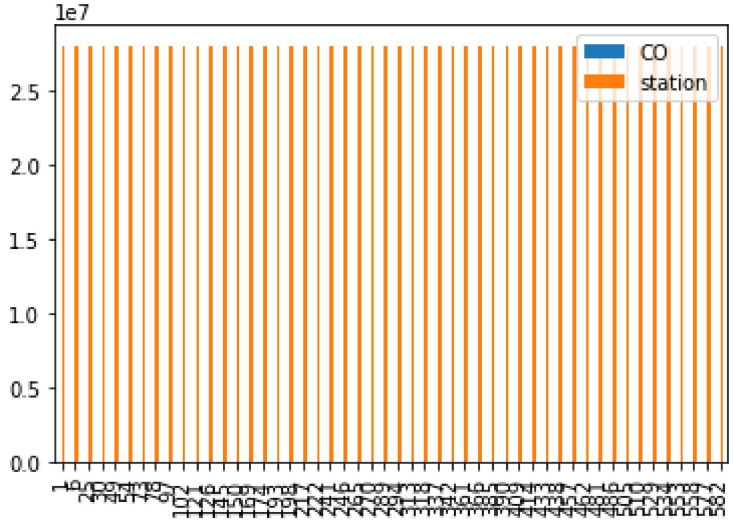


Bar chart

In [9]:
```
b=data[0:50]
```

In [10]:
```
b.plot.bar()
```

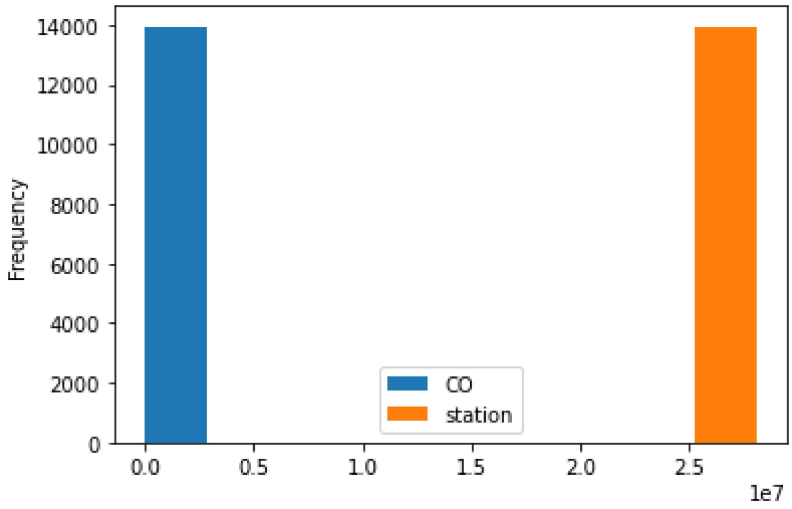
Out[10]: <AxesSubplot:>



Histogram

In [11]:
```
data.plot.hist()
```

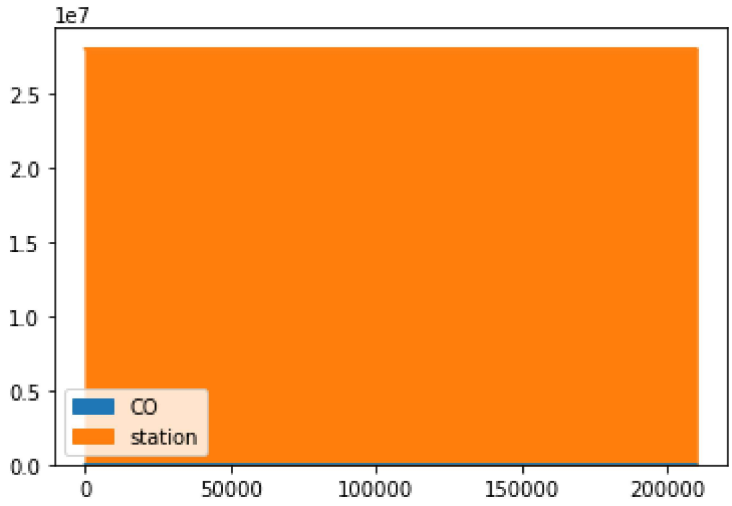
Out[11]:
```
<AxesSubplot:ylabel='Frequency'>
```



Area chart

In [12]:
```
data.plot.area()
```

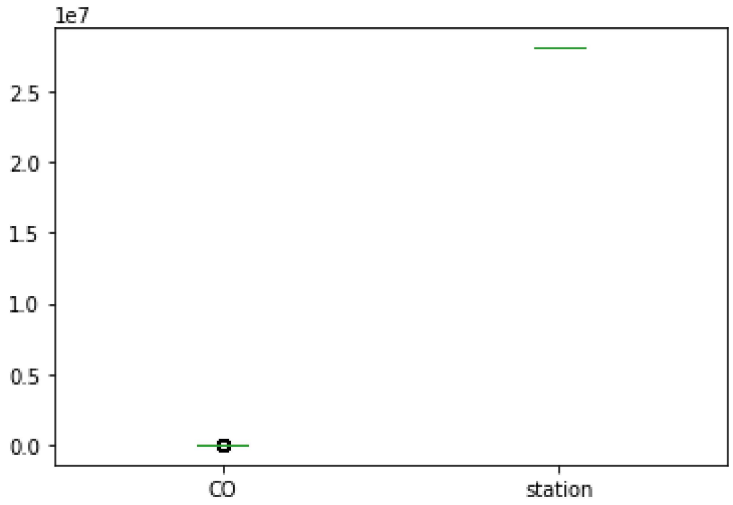
Out[12]:
```
<AxesSubplot:>
```



Box chart

In [13]:
```
data.plot.box()
```

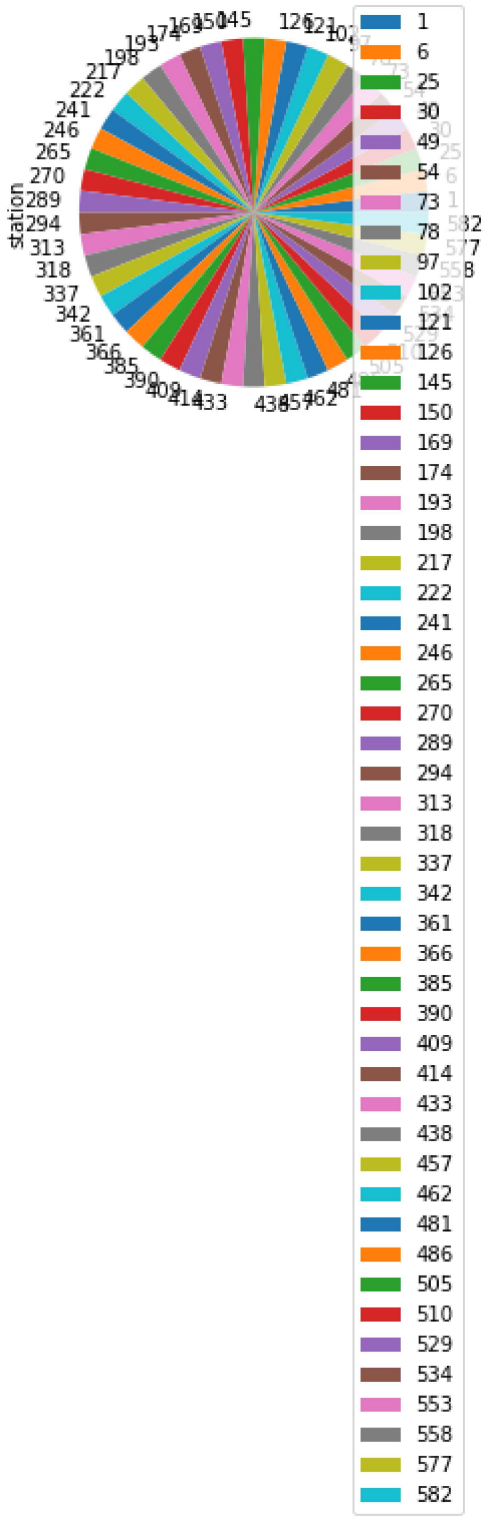
Out[13]: <AxesSubplot:>



Pie chart

In [14]:
```
b.plot.pie(y='station' )
```

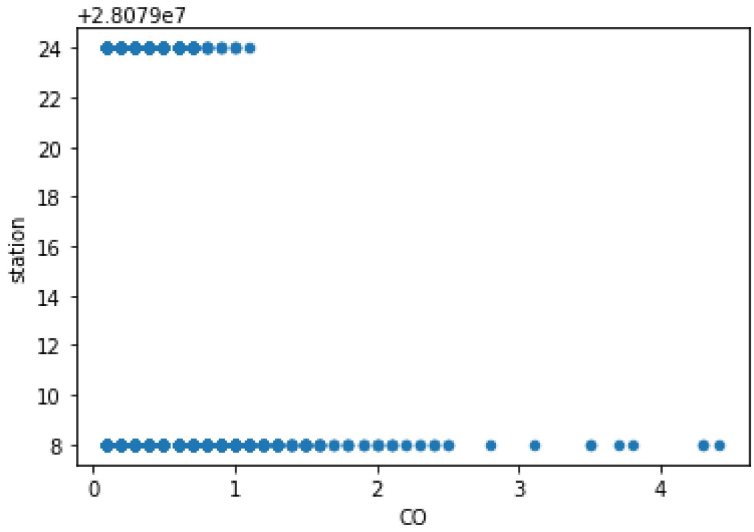
Out[14]: <AxesSubplot:ylabel='station'>



Scatter chart

In [15]:
```
data.plot.scatter(x='CO' ,y='station')
```

Out[15]: <AxesSubplot:xlabel='CO', ylabel='station'>



In [16]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 13946 entries, 1 to 210006
Data columns (total 14 columns):
 #   Column   Non-Null Count  Dtype  
---  ------   --------------  -----  
 0   date     13946 non-null  object 
 1   BEN      13946 non-null  float64
 2   CO       13946 non-null  float64
 3   EBE      13946 non-null  float64
 4   NMHC     13946 non-null  float64
 5   NO       13946 non-null  float64
 6   NO_2     13946 non-null  float64
 7   O_3      13946 non-null  float64
 8   PM10     13946 non-null  float64
 9   PM25     13946 non-null  float64
 10  SO_2     13946 non-null  float64
 11  TCH      13946 non-null  float64
 12  TOL      13946 non-null  float64
 13  station  13946 non-null  int64  
dtypes: float64(12), int64(1), object(1)
```

In [17]:
```
df.describe()
```

Out[17]:

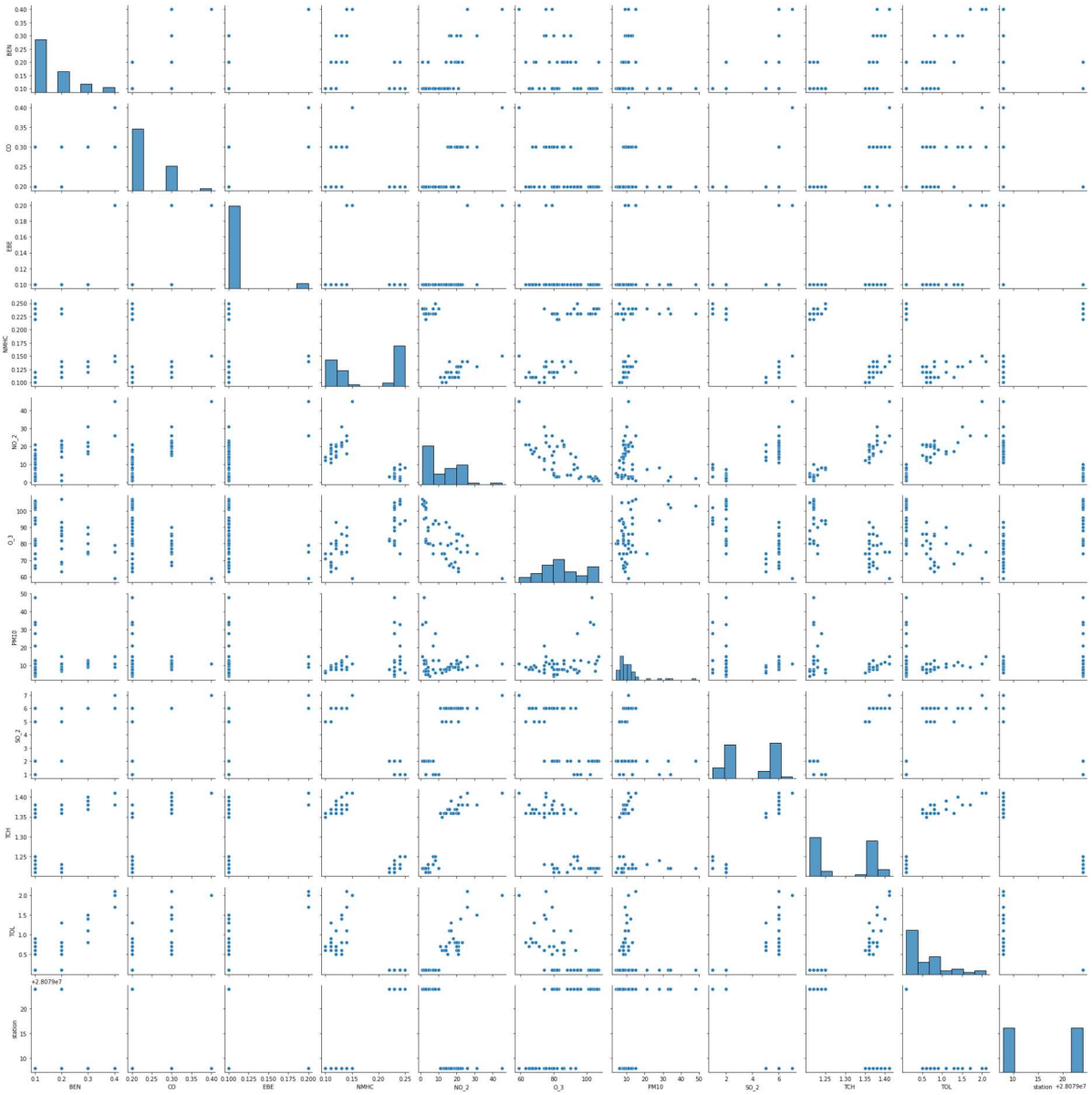
	BEN	CO	EBE	NMHC	NO	NO_2	
count	13946.000000	13946.000000	13946.000000	13946.000000	13946.000000	13946.000000	139
mean	0.375921	0.314793	0.306016	0.222302	17.589129	34.240929	
std	0.555093	0.207375	0.635475	0.082403	39.432216	30.654229	
min	0.100000	0.100000	0.100000	0.060000	1.000000	1.000000	
25%	0.100000	0.200000	0.100000	0.160000	1.000000	10.000000	
50%	0.200000	0.300000	0.100000	0.230000	4.000000	27.000000	
75%	0.400000	0.400000	0.300000	0.260000	18.000000	51.000000	
max	9.400000	4.400000	16.200001	1.290000	725.000000	346.000000	2

In [18]:
```
df1=df[['BEN', 'CO', 'EBE','NMHC', 'NO_2','O_3',
       'PM10', 'SO_2', 'TCH', 'TOL', 'station']]
```

EDA AND VISUALIZATION

In [19]:
```
sns.pairplot(df1[0:50])
```

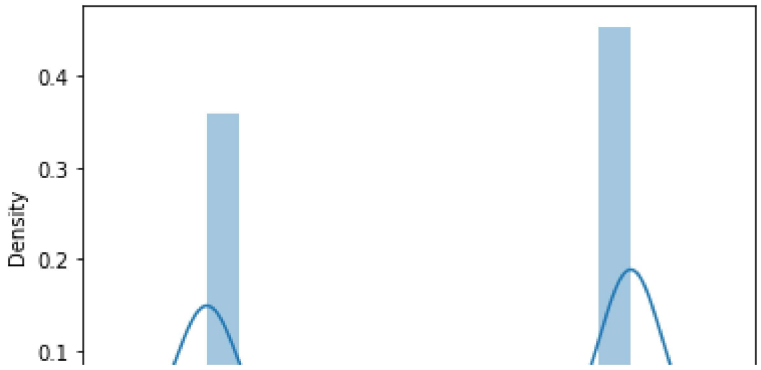
Out[19]: <seaborn.axisgrid.PairGrid at 0x21c472ae2b0>



In [20]:
```
sns.distplot(df1['station'])
```

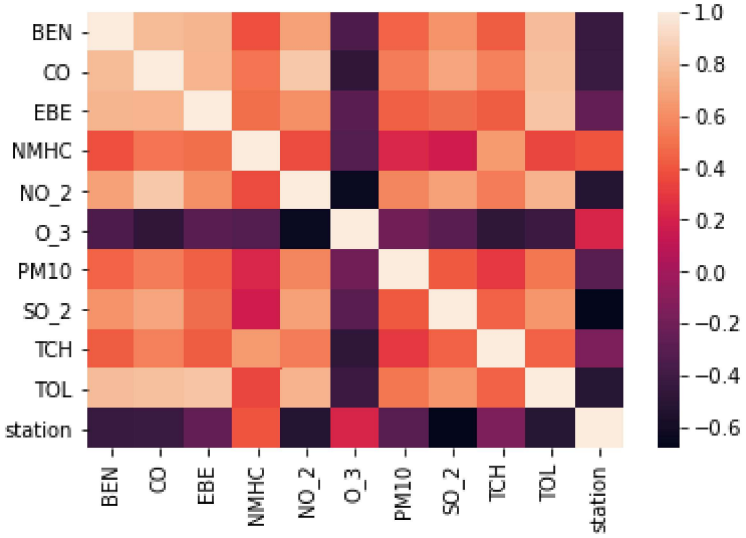
```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\distributions.py:2557: F
utureWarning: `distplot` is a deprecated function and will be removed in a
future version. Please adapt your code to use either `displot` (a figure-le
vel function with similar flexibility) or `histplot` (an axes-level functio
n for histograms).
  warnings.warn(msg, FutureWarning)
```

Out[20]: <AxesSubplot:xlabel='station', ylabel='Density'>



In [21]:
```
sns.heatmap(df1.corr())
```

Out[21]: <AxesSubplot:>



TO TRAIN THE MODEL AND MODEL BULDING

In [22]:
```
x=df[['BEN', 'CO', 'EBE','NMHC', 'NO_2','O_3',
       'PM10', 'SO_2', 'TCH', 'TOL']]
y=df['station']
```

In [23]:
```
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.3)
```

Linear Regression

In [24]:
```
from sklearn.linear_model import LinearRegression
lr=LinearRegression()
lr.fit(x_train,y_train)
```

Out[24]:
```
LinearRegression()
```

In [25]:
```
lr.intercept_
```

Out[25]:
```
28079022.368913267
```

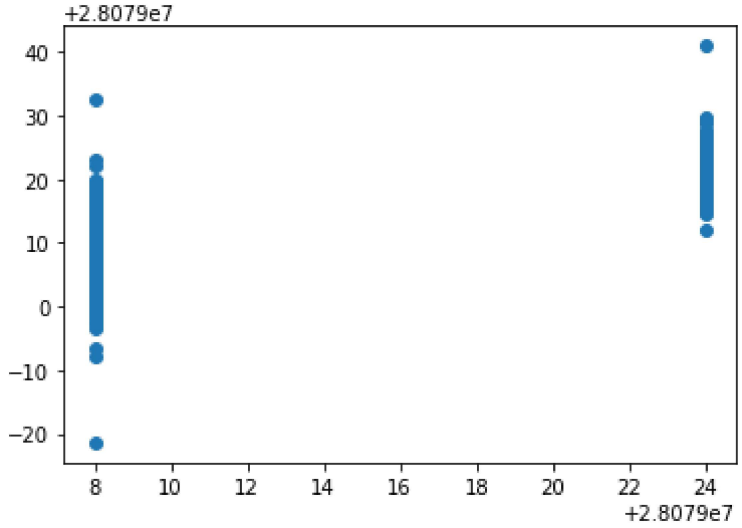
In [26]:
```
coeff=pd.DataFrame(lr.coef_,x.columns,columns=['Co-efficient'])
coeff
```

Out[26]:

	Co-efficient
BEN	-1.460058
CO	-6.015786
EBE	0.608080
NMHC	83.300354
NO_2	-0.030376
O_3	0.002628
PM10	0.013903
SO_2	-0.863560
TCH	-11.720057
TOL	-0.467070

In [27]:
```
prediction =lr.predict(x_test)
plt.scatter(y_test,prediction)
```

Out[27]: <matplotlib.collections.PathCollection at 0x21c5087c130>



ACCURACY

In [28]:
```
lr.score(x_test,y_test)
```

Out[28]: 0.8839778325566364

In [29]:
```
lr.score(x_train,y_train)
```

Out[29]: 0.8842048440834895

Ridge and Lasso

In [30]:
```
from sklearn.linear_model import Ridge,Lasso
```

In [31]:
```
rr=Ridge(alpha=10)
rr.fit(x_train,y_train)
```

Out[31]: Ridge(alpha=10)

Accuracy(Ridge)

In [32]:
```
rr.score(x_test,y_test)
```

Out[32]: 0.8601293298934984

In [33]:
```
rr.score(x_train,y_train)
```

Out[33]:
```
0.8610200538873044
```

In [34]:
```
la=Lasso(alpha=10)
la.fit(x_train,y_train)
```

Out[34]:
```
Lasso(alpha=10)
```

Accuracy(Lasso)

In [35]:
```
la.score(x_train,y_train)
```

Out[35]:
```
0.27795286038829814
```

In [36]:
```
la.score(x_test,y_test)
```

Out[36]:
```
0.26547438314303884
```

ElasticNet

In [37]:
```
from sklearn.linear_model import ElasticNet
en=ElasticNet()
en.fit(x_train,y_train)
```

Out[37]:
```
ElasticNet()
```

In [38]:
```
en.coef_
```

Out[38]:
```
array([ 0.        ,  0.        ,  0.07570043,  0.        , -0.04216055,
       -0.01178526,  0.01712636, -1.23403791,  0.        , -0.2442877 ])
```

In [39]:
```
en.intercept_
```

Out[39]:
```
28079024.890186843
```

In [40]:
```
prediction=en.predict(x_test)
```

In [41]:
```
en.score(x_test,y_test)
```

Out[41]:
```
0.4578629512038762
```

Evaluation Metrics

In [42]:
```
from sklearn import metrics
print(metrics.mean_absolute_error(y_test,prediction))
print(metrics.mean_squared_error(y_test,prediction))
print(np.sqrt(metrics.mean_squared_error(y_test,prediction)))
```

```
4.99357116534989
34.40451194506847
5.865535946959022
```

Logistic Regression

In [43]:
```
from sklearn.linear_model import LogisticRegression
```

In [44]:
```
feature_matrix=df[['BEN', 'CO', 'EBE','NMHC', 'NO_2','O_3',
       'PM10', 'SO_2', 'TCH', 'TOL' ]]
target_vector=df[ 'station']
```

In [45]:
```
feature_matrix.shape
```

Out[45]:
```
(13946, 10)
```

In [46]:
```
target_vector.shape
```

Out[46]:
```
(13946,)
```

In [47]:
```
from sklearn.preprocessing import StandardScaler
```

In [48]:
```
fs=StandardScaler().fit_transform(feature_matrix)
```

In [49]:
```
logr=LogisticRegression(max_iter=10000)
logr.fit(fs,target_vector)
```

Out[49]:
```
LogisticRegression(max_iter=10000)
```

In [50]:
```
observation=[[1,2,3,4,5,6,7,8,9,10]]
```

In [51]:
```
prediction=logr.predict(observation)
print(prediction)
```

```
[28079008]
```

In [52]:
```
logr.classes_
```

Out[52]:
```
array([28079008, 28079024], dtype=int64)
```

In [53]:
```
logr.score(fs,target_vector)
```

Out[53]:
```
0.9926143697117453
```

In [54]:
```
logr.predict_proba(observation)[0][0]
```

Out[54]:
```
1.0
```

In [55]:
```
logr.predict_proba(observation)
```

Out[55]:
```
array([[1.00000000e+00, 5.27113072e-18]])
```

Random Forest

In [56]:
```
from sklearn.ensemble import RandomForestClassifier
```

In [57]:
```
rfc=RandomForestClassifier()
rfc.fit(x_train,y_train)
```

Out[57]:
```
RandomForestClassifier()
```

In [58]:
```
parameters={'max_depth':[1,2,3,4,5],
            'min_samples_leaf':[5,10,15,20,25],
            'n_estimators':[10,20,30,40,50]
}
```

In [59]:
```
from sklearn.model_selection import GridSearchCV
grid_search =GridSearchCV(estimator=rfc,param_grid=parameters,cv=2,scoring="ac
grid_search.fit(x_train,y_train)
```

Out[59]:
```
GridSearchCV(cv=2, estimator=RandomForestClassifier(),
             param_grid={'max_depth': [1, 2, 3, 4, 5],
                         'min_samples_leaf': [5, 10, 15, 20, 25],
                         'n_estimators': [10, 20, 30, 40, 50]},
             scoring='accuracy')
```

In [60]:
```
grid_search.best_score_
```

Out[60]:
```
0.9961073550501947
```

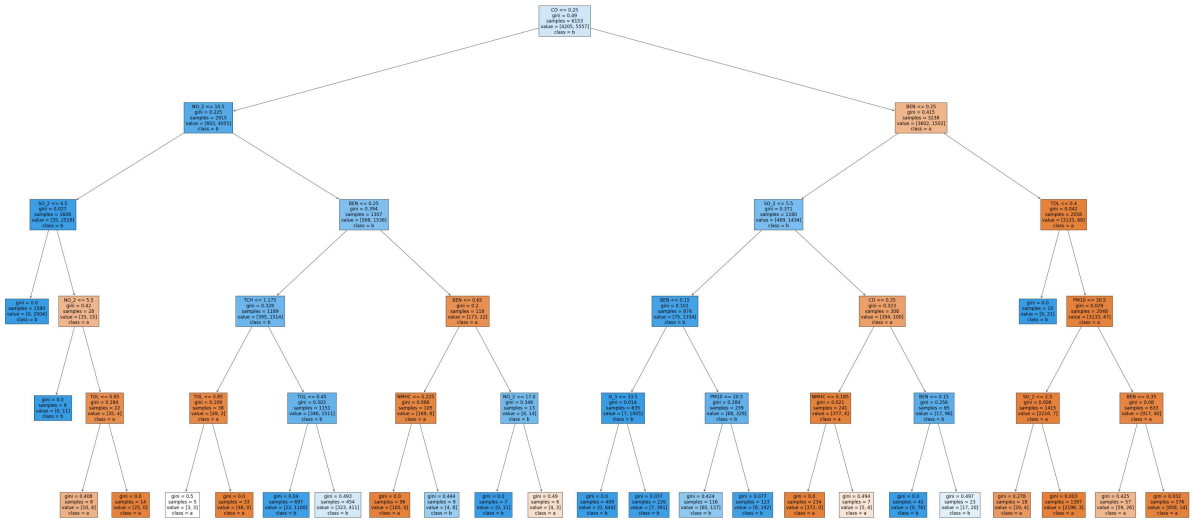
In [61]:
```
rfc_best=grid_search.best_estimator_
```

In [62]:
```
from sklearn.tree import plot_tree

plt.figure(figsize=(80,40))
plot_tree(rfc_best.estimators_[5],feature_names=x.columns,class_names=['a','b'
```

Out[62]:
```
[Text(2110.695652173913, 1993.2, 'CO <= 0.25\ngini = 0.49\nsamples = 6153\nva
lue = [4205, 5557]\nclass = b'),
 Text(776.3478260869565, 1630.8000000000002, 'NO_2 <= 10.5\ngini = 0.225\nsam
ples = 2915\nvalue = [603, 4055]\nclass = b'),
 Text(194.08695652173913, 1268.4, 'SO_2 <= 4.5\ngini = 0.027\nsamples = 1608
\nvalue = [35, 2519]\nclass = b'),
 Text(97.04347826086956, 906.0, 'gini = 0.0\nsamples = 1580\nvalue = [0, 250
4]\nclass = b'),
 Text(291.1304347826087, 906.0, 'NO_2 <= 5.5\ngini = 0.42\nsamples = 28\nvalu
e = [35, 15]\nclass = a'),
 Text(194.08695652173913, 543.5999999999999, 'gini = 0.0\nsamples = 6\nvalue
= [0, 11]\nclass = b'),
 Text(388.17391304347825, 543.5999999999999, 'TOL <= 0.65\ngini = 0.184\nsamp
les = 22\nvalue = [35, 4]\nclass = a'),
 Text(291.1304347826087, 181.19999999999982, 'gini = 0.408\nsamples = 8\nvalu
e = [10, 4]\nclass = a'),
 Text(485.2173913043478, 181.19999999999982, 'gini = 0.0\nsamples = 14\nvalue
= [25, 0]\nclass = a'),
 Text(1358.608695652174, 1268.4, 'BEN <= 0.25\ngini = 0.394\nsamples = 1307\n
value = [568, 1536]\nclass = b'),
 Text(970.4347826086956, 906.0, 'TCH <= 1.175\ngini = 0.328\nsamples = 1189\n
value = [395, 1514]\nclass = b'),
 Text(776.3478260869565, 543.5999999999999, 'TOL <= 0.85\ngini = 0.109\nsampl
es = 38\nvalue = [49, 3]\nclass = a'),
 Text(679.304347826087, 181.19999999999982, 'gini = 0.5\nsamples = 5\nvalue =
[3, 3]\nclass = a'),
 Text(873.391304347826, 181.19999999999982, 'gini = 0.0\nsamples = 33\nvalue
= [46, 0]\nclass = a'),
 Text(1164.5217391304348, 543.5999999999999, 'TOL <= 0.45\ngini = 0.303\nsamp
les = 1151\nvalue = [346, 1511]\nclass = b'),
 Text(1067.4782608695652, 181.19999999999982, 'gini = 0.04\nsamples = 697\nva
lue = [23, 1100]\nclass = b'),
 Text(1261.5652173913043, 181.19999999999982, 'gini = 0.493\nsamples = 454\nv
alue = [323, 411]\nclass = b'),
 Text(1746.782608695652, 906.0, 'BEN <= 0.65\ngini = 0.2\nsamples = 118\nvalu
e = [173, 22]\nclass = a'),
 Text(1552.695652173913, 543.5999999999999, 'NMHC <= 0.225\ngini = 0.086\nsam
ples = 105\nvalue = [169, 8]\nclass = a'),
 Text(1455.6521739130435, 181.19999999999982, 'gini = 0.0\nsamples = 96\nvalu
e = [165, 0]\nclass = a'),
 Text(1649.7391304347825, 181.19999999999982, 'gini = 0.444\nsamples = 9\nval
ue = [4, 8]\nclass = b'),
 Text(1940.8695652173913, 543.5999999999999, 'NO_2 <= 17.0\ngini = 0.346\nsam
ples = 13\nvalue = [4, 14]\nclass = b'),
 Text(1843.8260869565217, 181.19999999999982, 'gini = 0.0\nsamples = 7\nvalue
= [0, 11]\nclass = b'),
 Text(2037.9130434782608, 181.19999999999982, 'gini = 0.49\nsamples = 6\nvalu
e = [4, 3]\nclass = a'),
 Text(3445.0434782608695, 1630.8000000000002, 'BEN <= 0.25\ngini = 0.415\nsam
ples = 3238\nvalue = [3602, 1502]\nclass = a'),
 Text(2911.304347826087, 1268.4, 'SO_2 <= 5.5\ngini = 0.371\nsamples = 1180\n
value = [469, 1434]\nclass = b'),
 Text(2523.1304347826085, 906.0, 'BEN <= 0.15\ngini = 0.101\nsamples = 874\nv
alue = [75, 1334]\nclass = b'),
 Text(2329.0434782608695, 543.5999999999999, 'O_3 <= 33.5\ngini = 0.014\nsamp
les = 635\nvalue = [7, 1005]\nclass = b'),
 Text(2232.0, 181.19999999999982, 'gini = 0.0\nsamples = 409\nvalue = [0, 64
```

```
4]\nclass = b'),
 Text(2426.086956521739, 181.19999999999982, 'gini = 0.037\nsamples = 226\nva
lue = [7, 361]\nclass = b'),
 Text(2717.217391304348, 543.5999999999999, 'PM10 <= 20.5\ngini = 0.284\nsamp
les = 239\nvalue = [68, 329]\nclass = b'),
 Text(2620.173913043478, 181.19999999999982, 'gini = 0.424\nsamples = 116\nva
lue = [60, 137]\nclass = b'),
 Text(2814.2608695652175, 181.19999999999982, 'gini = 0.077\nsamples = 123\nv
alue = [8, 192]\nclass = b'),
 Text(3299.478260869565, 906.0, 'CO <= 0.35\ngini = 0.323\nsamples = 306\nval
ue = [394, 100]\nclass = a'),
 Text(3105.391304347826, 543.5999999999999, 'NMHC <= 0.185\ngini = 0.021\nsam
ples = 241\nvalue = [377, 4]\nclass = a'),
 Text(3008.3478260869565, 181.19999999999982, 'gini = 0.0\nsamples = 234\nval
ue = [372, 0]\nclass = a'),
 Text(3202.4347826086955, 181.19999999999982, 'gini = 0.494\nsamples = 7\nval
ue = [5, 4]\nclass = a'),
 Text(3493.565217391304, 543.5999999999999, 'BEN <= 0.15\ngini = 0.256\nsampl
es = 65\nvalue = [17, 96]\nclass = b'),
 Text(3396.5217391304345, 181.19999999999982, 'gini = 0.0\nsamples = 42\nvalu
e = [0, 76]\nclass = b'),
 Text(3590.608695652174, 181.19999999999982, 'gini = 0.497\nsamples = 23\nval
ue = [17, 20]\nclass = b'),
 Text(3978.782608695652, 1268.4, 'TOL <= 0.4\ngini = 0.042\nsamples = 2058\nv
alue = [3133, 68]\nclass = a'),
 Text(3881.7391304347825, 906.0, 'gini = 0.0\nsamples = 10\nvalue = [0, 21]\n
class = b'),
 Text(4075.8260869565215, 906.0, 'PM10 <= 30.5\ngini = 0.029\nsamples = 2048
\nvalue = [3133, 47]\nclass = a'),
 Text(3881.7391304347825, 543.5999999999999, 'SO_2 <= 2.5\ngini = 0.006\nsamp
les = 1415\nvalue = [2216, 7]\nclass = a'),
 Text(3784.695652173913, 181.19999999999982, 'gini = 0.278\nsamples = 18\nval
ue = [20, 4]\nclass = a'),
 Text(3978.782608695652, 181.19999999999982, 'gini = 0.003\nsamples = 1397\nv
alue = [2196, 3]\nclass = a'),
 Text(4269.913043478261, 543.5999999999999, 'BEN <= 0.35\ngini = 0.08\nsample
s = 633\nvalue = [917, 40]\nclass = a'),
 Text(4172.869565217391, 181.19999999999982, 'gini = 0.425\nsamples = 57\nval
ue = [59, 26]\nclass = a'),
 Text(4366.95652173913, 181.19999999999982, 'gini = 0.032\nsamples = 576\nval
ue = [858, 14]\nclass = a')]
```



Accuracy

Linear Regression

In [63]:
```
lr.score(x_train,y_train)
```

Out[63]: 0.8842048440834895

Ridge Regression

In [64]:
```
rr.score(x_train,y_train)
```

Out[64]: 0.8610200538873044

Lasso Regression

In [65]:
```
la.score(x_test,y_test)
```

Out[65]: 0.26547438314303884

ElasticNet Regression

In [66]:
```
en.score(x_test,y_test)
```

Out[66]: 0.4578629512038762

Logistic Regression

In [67]:
```
logr.score(fs,target_vector)
```

Out[67]:
```
0.9926143697117453
```

Random Forest

In [68]:
```
grid_search.best_score_
```

Out[68]:
```
0.9961073550501947
```

Conclusion

RandomForest for this dataset