In [87]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.neighbors import KNeighborsRegressor
from sklearn.metrics import mean_squared_error, accuracy_score, cla
```

In [88]:
```
df = pd.read_csv("AirQualityUCI.csv",sep=";",decimal=",",low_memory
df.head()
```

Out[88]:

	Date	Time	CO(GT)	PT08.S1(CO)	NMHC(GT)	C6H6(GT)	PT08
0	10/03/2004	18.00.00	2.6	1360.0	150.0	11.9	
1	10/03/2004	19.00.00	2.0	1292.0	112.0	9.4	
2	10/03/2004	20.00.00	2.2	1402.0	88.0	9.0	
3	10/03/2004	21.00.00	2.2	1376.0	80.0	9.2	
4	10/03/2004	22.00.00	1.6	1272.0	51.0	6.5	

In [89]:
```
df.shape
```

Out[89]:
```
(9471, 17)
```

In [90]:
```
df.describe()
```

Out[90]:

	CO(GT)	PT08.S1(CO)	NMHC(GT)	C6H6(GT)	PT08.S2(NMH
count	9357.000000	9357.000000	9357.000000	9357.000000	9357.0000
mean	-34.207524	1048.990061	-159.090093	1.865683	894.5952
std	77.657170	329.832710	139.789093	41.380206	342.3332
min	-200.000000	-200.000000	-200.000000	-200.000000	-200.0000
25%	0.600000	921.000000	-200.000000	4.000000	711.0000
50%	1.500000	1053.000000	-200.000000	7.900000	895.0000
75%	2.600000	1221.000000	-200.000000	13.600000	1105.0000
max	11.900000	2040.000000	1189.000000	63.700000	2214.0000

In [91]:
```
df = df.replace(-200,np.nan)
```

In [92]:
```
df.describe()
```

Out[92]:

	CO(GT)	PT08.S1(CO)	NMHC(GT)	C6H6(GT)	PT08.S2(NMH
count	7674.000000	8991.000000	914.000000	8991.000000	8991.0000
mean	2.152750	1099.833166	218.811816	10.083105	939.1533
std	1.453252	217.080037	204.459921	7.449820	266.8314
min	0.100000	647.000000	7.000000	0.100000	383.0000
25%	1.100000	937.000000	67.000000	4.400000	734.5000
50%	1.800000	1063.000000	150.000000	8.200000	909.0000
75%	2.900000	1231.000000	297.000000	14.000000	1116.0000
max	11.900000	2040.000000	1189.000000	63.700000	2214.0000

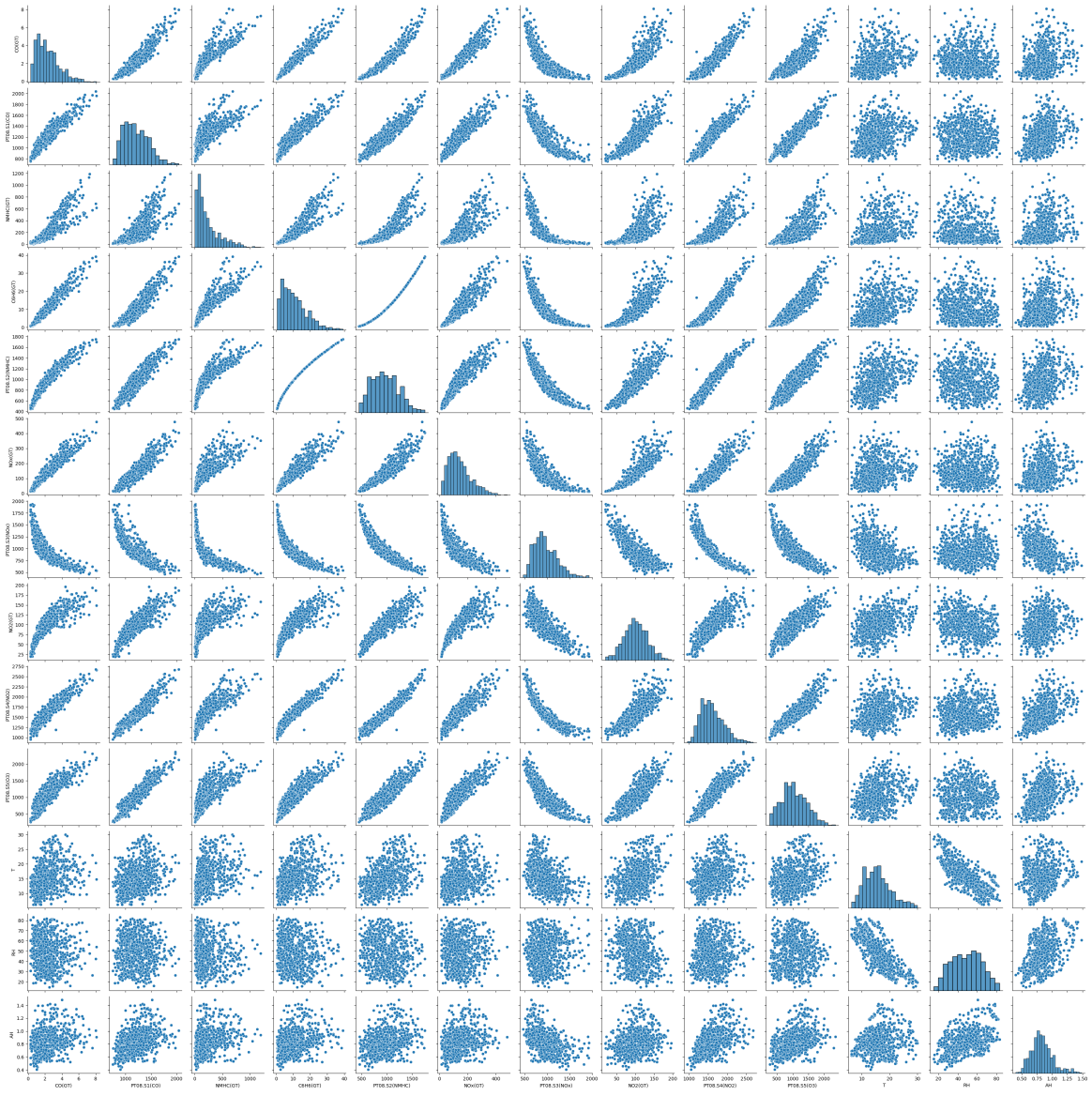
In [93]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 9471 entries, 0 to 9470
Data columns (total 17 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   Date           9357 non-null   object 
 1   Time           9357 non-null   object 
 2   CO(GT)         7674 non-null   float64
 3   PT08.S1(CO)    8991 non-null   float64
 4   NMHC(GT)       914 non-null    float64
 5   C6H6(GT)       8991 non-null   float64
 6   PT08.S2(NMHC)  8991 non-null   float64
 7   NOx(GT)        7718 non-null   float64
 8   PT08.S3(NOx)   8991 non-null   float64
 9   NO2(GT)        7715 non-null   float64
 10  PT08.S4(NO2)   8991 non-null   float64
 11  PT08.S5(O3)    8991 non-null   float64
 12  T              8991 non-null   float64
 13  RH             8991 non-null   float64
 14  AH             8991 non-null   float64
 15  Unnamed: 15    0 non-null      float64
 16  Unnamed: 16    0 non-null      float64
dtypes: float64(15), object(2)
memory usage: 1.2+ MB
```

In [94]:
```
df = df.drop(columns=["Unnamed: 15","Unnamed: 16"])
df = df.dropna()
print(df.info())
print(df.shape)
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 827 entries, 0 to 1230
Data columns (total 15 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   Date           827 non-null    object 
 1   Time           827 non-null    object 
 2   CO(GT)         827 non-null    float64
 3   PT08.S1(CO)    827 non-null    float64
 4   NMHC(GT)       827 non-null    float64
 5   C6H6(GT)       827 non-null    float64
 6   PT08.S2(NMHC)  827 non-null    float64
 7   NOx(GT)        827 non-null    float64
 8   PT08.S3(NOx)   827 non-null    float64
 9   NO2(GT)        827 non-null    float64
 10  PT08.S4(NO2)   827 non-null    float64
 11  PT08.S5(O3)    827 non-null    float64
 12  T              827 non-null    float64
 13  RH             827 non-null    float64
 14  AH             827 non-null    float64
dtypes: float64(13), object(2)
memory usage: 103.4+ KB
None
(827, 15)
```

In [95]:
```
sns.pairplot(df)
plt.show()
```



In [96]:
```
x = df[['T', 'RH', 'AH',
        'PT08.S1(CO)', 'PT08.S2(NMHC)',
        'PT08.S3(NOx)', 'PT08.S4(NO2)', 'PT08.S5(O3)']]

y = df[['CO(GT)', 'NO2(GT)', 'NMHC(GT)']]
```

In [97]:
```
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size
```

In [98]:
```
lr = LinearRegression()
lr.fit(x_train,y_train)
lr.score(x_test,y_test)
```

Out[98]: 0.8783303966353667

In [99]:
```
predict= lr.predict(x)
y_pred = lr.predict(x_test)
print(predict)
```

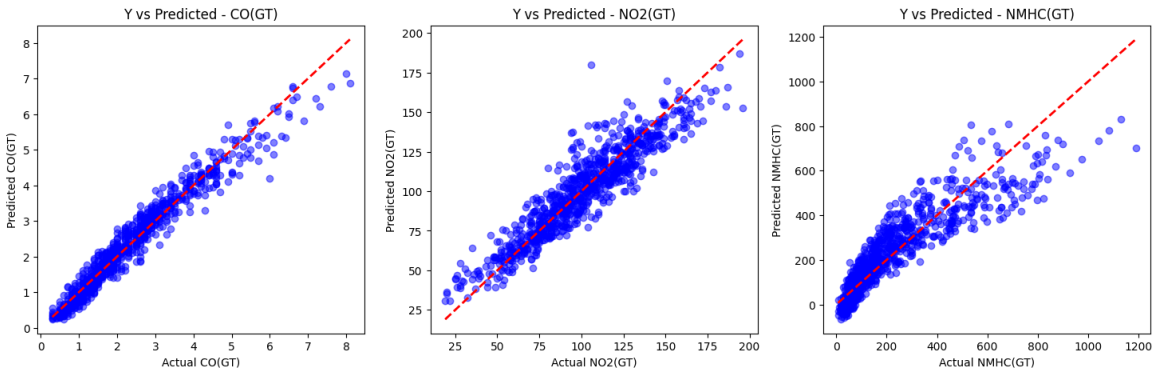
```
[[  3.17348135 111.64814472 288.82446478]
 [  2.78711689 103.85687253 231.35508484]
 [  2.80463596 113.43480914 155.66451163]
 ...
 [  3.09676468 109.08900584 383.82767278]
 [  3.03214566 112.87501141 335.0666682 ]
 [  3.23093203 117.55282217 373.72525041]]
```

In [100…
```
pred_df = pd.DataFrame(predict, columns=['Predicted_CO', 'Predicted
pred_df.head()
```

Out[100…

	Predicted_CO	Predicted_NO2	Predicted_NMHC
0	3.173481	111.648145	288.824465
1	2.787117	103.856873	231.355085
2	2.804636	113.434809	155.664512
3	2.744741	112.419620	164.052277
4	2.139227	97.800635	94.988708

In [101…
```
plt.figure(figsize=(18, 5))

for i, col in enumerate(y.columns):
    plt.subplot(1, 3, i+1)
    plt.scatter(y[col], pred_df.iloc[:, i], alpha=0.5, color="blue"
    plt.plot([y[col].min(), y[col].max()],
             [y[col].min(), y[col].max()], "r--", linewidth=2)
    plt.xlabel(f"Actual {col}")
    plt.ylabel(f"Predicted {col}")
    plt.title(f"Y vs Predicted - {col}")


plt.show()
```



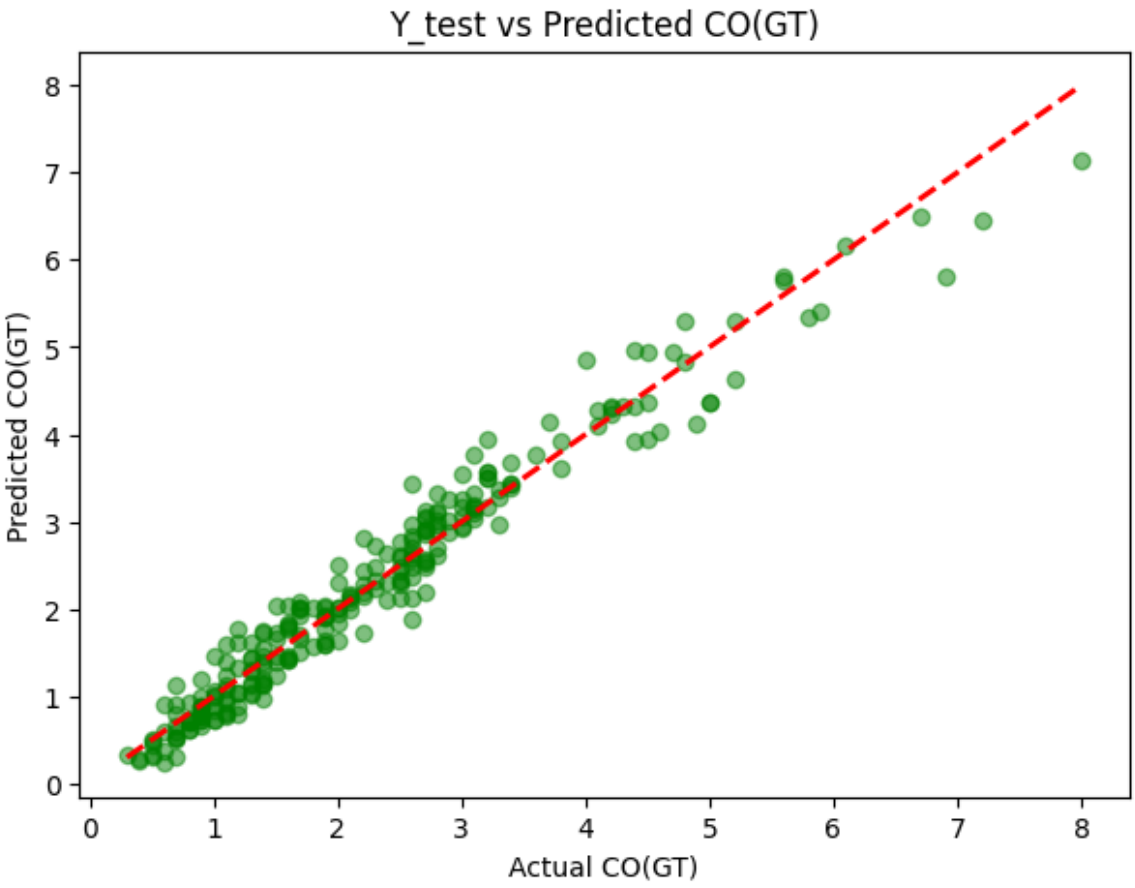
In [102…
```
results = {"Pollutant": [], "Model": [], "RMSE": [], "R2": []}
```

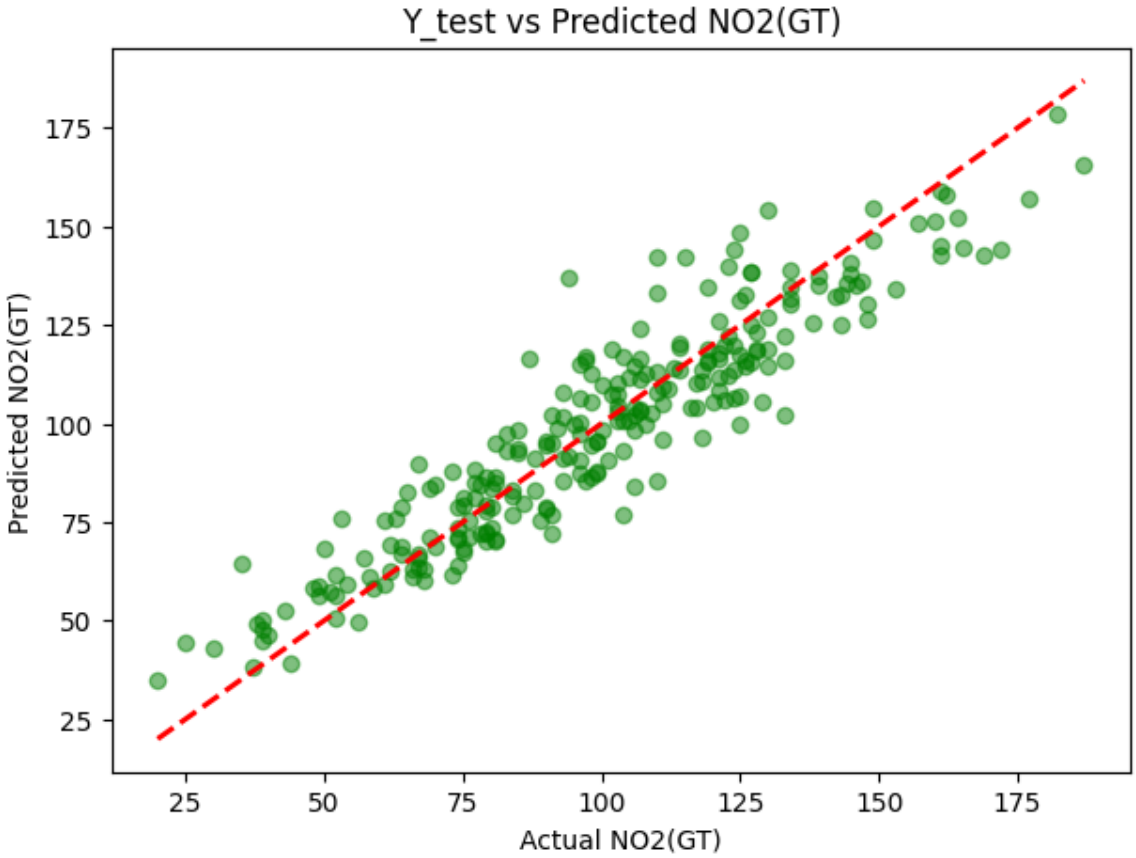
In [103…
```
y_pred_lin = lr.predict(x_test)   # predict only on test data
# Linear Regression metrics
mse_lin = mean_squared_error(y_test.iloc[:, i], y_pred_lin[:, i])
rmse_lin = np.sqrt(mse_lin)
r2_lin = r2_score(y_test.iloc[:, i], y_pred_lin[:, i])
results["Pollutant"].append(col)
```

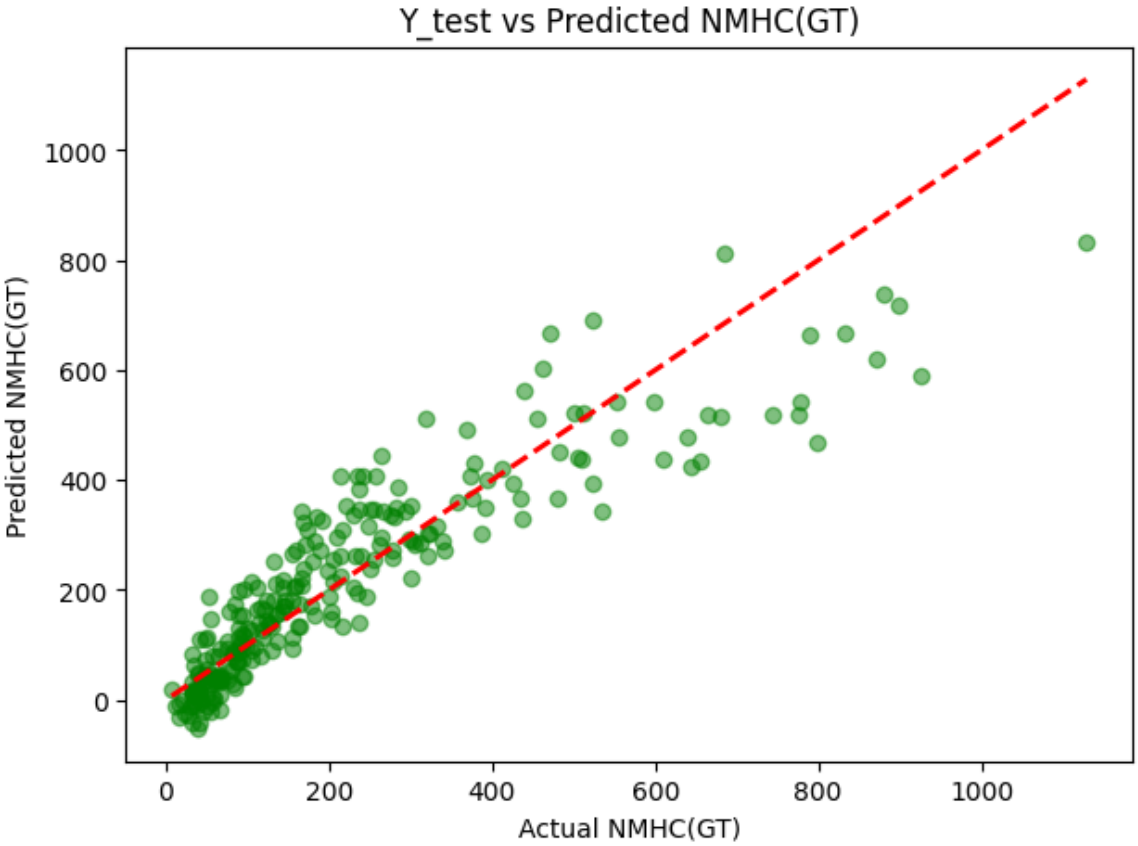
```
results["Model"].append("Linear Regression")
results["RMSE"].append(rmse_lin)
results["R2"].append(r2_lin)
```

In [104…

```
for i,col in enumerate(y.columns):
    plt.figure(figsize= (7,5))
    plt.scatter(y_test.iloc[:,i],y_pred_lin[:,i],alpha=0.5,color =
    plt.plot([y_test.iloc[:, i].min(), y_test.iloc[:, i].max()],
             [y_test.iloc[:, i].min(), y_test.iloc[:, i].max()],
             "r--", linewidth=2)
    plt.xlabel(f"Actual {col}")
    plt.ylabel(f"Predicted {col}")
    plt.title(f"Y_test vs Predicted {col}")
    plt.show()
```







In [105…
```
df = pd.concat([df.reset_index(drop=True), pred_df], axis=1)
```

In [106…
```
df.head()
```

Out[106…

	Date	Time	CO(GT)	PT08.S1(CO)	NMHC(GT)	C6H6(GT)	PT08
0	10/03/2004	18.00.00	2.6	1360.0	150.0	11.9	
1	10/03/2004	19.00.00	2.0	1292.0	112.0	9.4	
2	10/03/2004	20.00.00	2.2	1402.0	88.0	9.0	
3	10/03/2004	21.00.00	2.2	1376.0	80.0	9.2	
4	10/03/2004	22.00.00	1.6	1272.0	51.0	6.5	

In [107…

```
knn_model = KNeighborsRegressor()
knn_model.fit(x_train,y_train)
print("Score : ",knn_model.score(x_test,y_test))
y_pred_knn = knn_model.predict(x_test)
```

```
Score :  0.8832258223309667
```

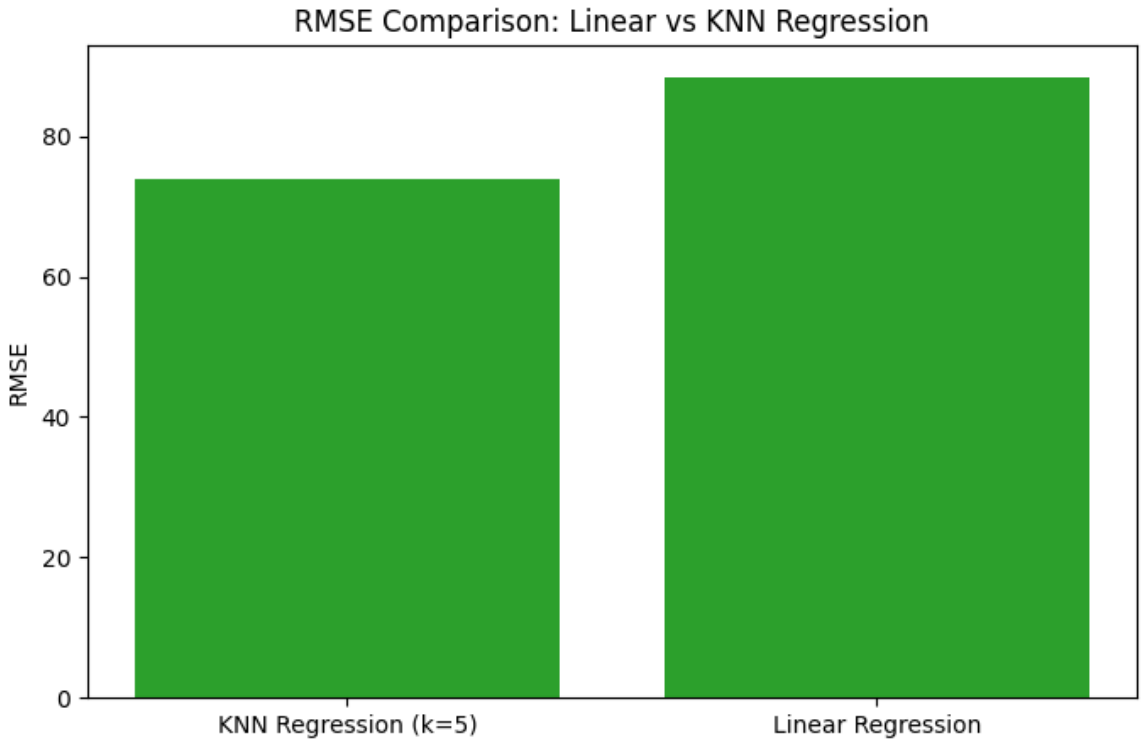
In [108…

```
for i, col in enumerate(y.columns):
    mse_knn = mean_squared_error(y_test.iloc[:, i], y_pred_knn[:, i
    rmse_knn = np.sqrt(mse_knn)
    r2_knn = r2_score(y_test.iloc[:, i], y_pred_knn[:, i])
    results["Pollutant"].append(col)
    results["Model"].append("KNN Regression (k=5)")
    results["RMSE"].append(rmse_knn)
    results["R2"].append(r2_knn)
results_df = pd.DataFrame(results)
print(results_df)
```

```
  Pollutant                 Model       RMSE        R2
0  NMHC(GT)     Linear Regression  88.451992  0.816715
1    CO(GT)  KNN Regression (k=5)   0.324897  0.944814
2   NO2(GT)  KNN Regression (k=5)  13.101629  0.833054
3  NMHC(GT)  KNN Regression (k=5)  73.972902  0.871809
```

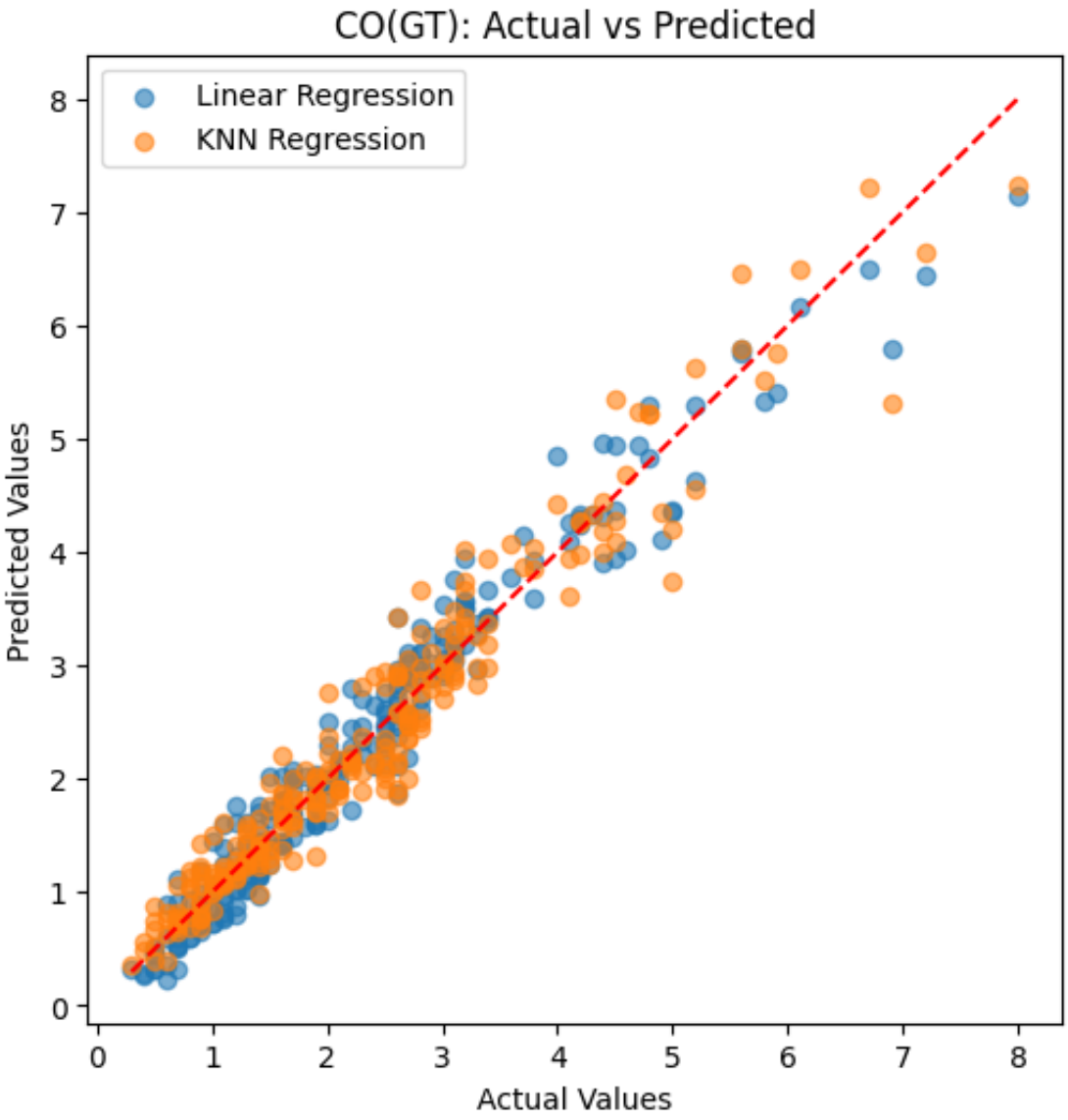
In [ ]:

```
plt.figure(figsize=(8,5))
for pollutant in y.columns:
    subset = results_df[results_df["Pollutant"] == pollutant]
    plt.bar(subset["Model"], subset["RMSE"], label=pollutant)
plt.title("RMSE Comparison: Linear vs KNN Regression")
plt.ylabel("RMSE")
plt.show()
```



In [110…

```
# Scatter plot: Actual vs Predicted for CO (example)
plt.figure(figsize=(6,6))
plt.scatter(y_test["CO(GT)"], y_pred_lin[:,0], alpha=0.6, label="Li
plt.scatter(y_test["CO(GT)"], y_pred_knn[:,0], alpha=0.6, label="KN
plt.plot([y_test["CO(GT)"].min(), y_test["CO(GT)"].max()],
         [y_test["CO(GT)"].min(), y_test["CO(GT)"].max()],
         "r--")  # Perfect prediction line
plt.title("CO(GT): Actual vs Predicted")
plt.xlabel("Actual Values")
plt.ylabel("Predicted Values")
plt.legend()
plt.show()
```



In [111…

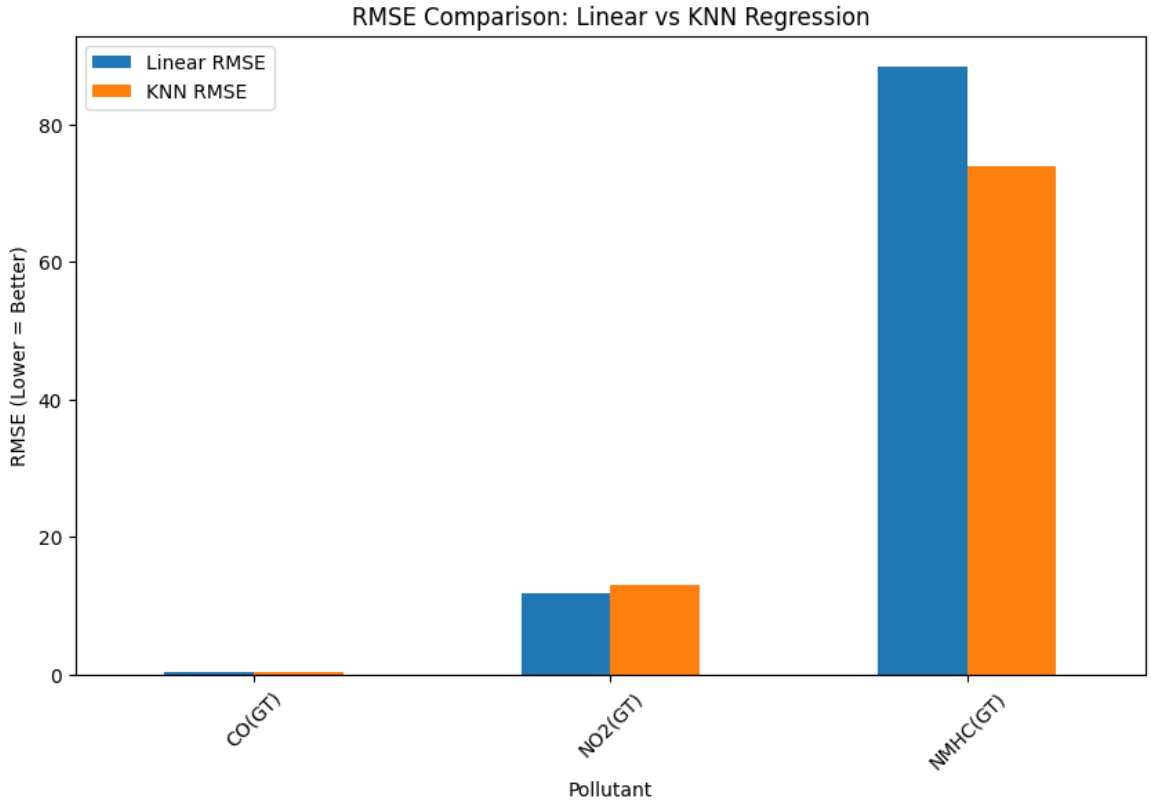
```
results = []

for i, col in enumerate(y.columns):
    # Linear Regression
    mse_lin = mean_squared_error(y_test.iloc[:, i], y_pred_lin[:, i
    rmse_lin = np.sqrt(mse_lin)
    r2_lin = r2_score(y_test.iloc[:, i], y_pred_lin[:, i])

    # KNN Regression
    mse_knn = mean_squared_error(y_test.iloc[:, i], y_pred_knn[:, i
    rmse_knn = np.sqrt(mse_knn)
    r2_knn = r2_score(y_test.iloc[:, i], y_pred_knn[:, i])

    results.append({
        "Pollutant": col,
        "Linear RMSE": rmse_lin,
        "Linear R²": r2_lin,
        "KNN RMSE": rmse_knn,
        "KNN R²": r2_knn
    })

    results_df = pd.DataFrame(results)
print("\n🔷 Model Comparison Results:")
```

```
print(results_df)
```

```
🔷 Model Comparison Results:
  Pollutant  Linear RMSE  Linear R²   KNN RMSE    KNN R²
0    CO(GT)     0.291171   0.955677   0.324897  0.944814
1   NO2(GT)    11.885894   0.862599  13.101629  0.833054
2  NMHC(GT)    88.451992   0.816715  73.972902  0.871809
```

In [112…

```
results_df.plot(
    x="Pollutant",
    y=["Linear RMSE", "KNN RMSE"],
    kind="bar",
    figsize=(10, 6)
)
plt.title("RMSE Comparison: Linear vs KNN Regression")
plt.ylabel("RMSE (Lower = Better)")
plt.xticks(rotation=45)
plt.show()
```



In [113…

```
pollutant = y.columns[0]

plt.figure(figsize=(12,5))
plt.subplot(1, 2, 1)
plt.scatter(y_test.iloc[:,0], y_pred_lin[:,0], alpha=0.6, color='bl
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.title(f"Linear Regression: {pollutant}")

plt.subplot(1, 2, 2)
plt.scatter(y_test.iloc[:,0], y_pred_knn[:,0], alpha=0.6, color='gr
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.title(f"KNN Regression: {pollutant}")
```

```
plt.tight_layout()
plt.show()
```