Exploratory Analysis

Libraries

In [1]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from statsmodels.tsa.seasonal import seasonal_decompose
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.tsa.stattools import acf, pacf, adfuller, kpss
```

In [2]:
```
import warnings
warnings.filterwarnings('ignore')
```

Data Overview

In [3]:
```
data = pd.read_csv("daily_data.csv")
```

In [4]:
```
data.head()
```

Out[4]:

	date	daily_avg_benzene	datetime
0	2004-03-10	8.460790	2004-03-10T00:00:00Z
1	2004-03-11	7.989058	2004-03-11T00:00:00Z
2	2004-03-12	12.129509	2004-03-12T00:00:00Z
3	2004-03-13	10.922887	2004-03-13T00:00:00Z
4	2004-03-14	9.631442	2004-03-14T00:00:00Z

In [5]:
```
df = data.drop("datetime", axis='columns')
```

In [6]:
```
df.head()
```

Out[6]:

	date	daily_avg_benzene
0	2004-03-10	8.460790
1	2004-03-11	7.989058
2	2004-03-12	12.129509
3	2004-03-13	10.922887
4	2004-03-14	9.631442

In [7]:
```python
# Statistics
df.describe()
```

Out[7]:

	daily_avg_benzene
count	391.000000
mean	10.173870
std	4.308602
min	1.431244
25%	6.921344
50%	9.984321
75%	13.112391
max	24.395876

In [8]:
```python
# Missing Values
df.isnull().sum()
```

Out[8]:
```
date                 0
daily_avg_benzene    0
dtype: int64
```

In [9]:
```python
# Data Types
df.dtypes
```

Out[9]:
```
date                  object
daily_avg_benzene    float64
dtype: object
```

In [10]:
```python
# Length of Dataset
len(df)
```

Out[10]:
```
391
```

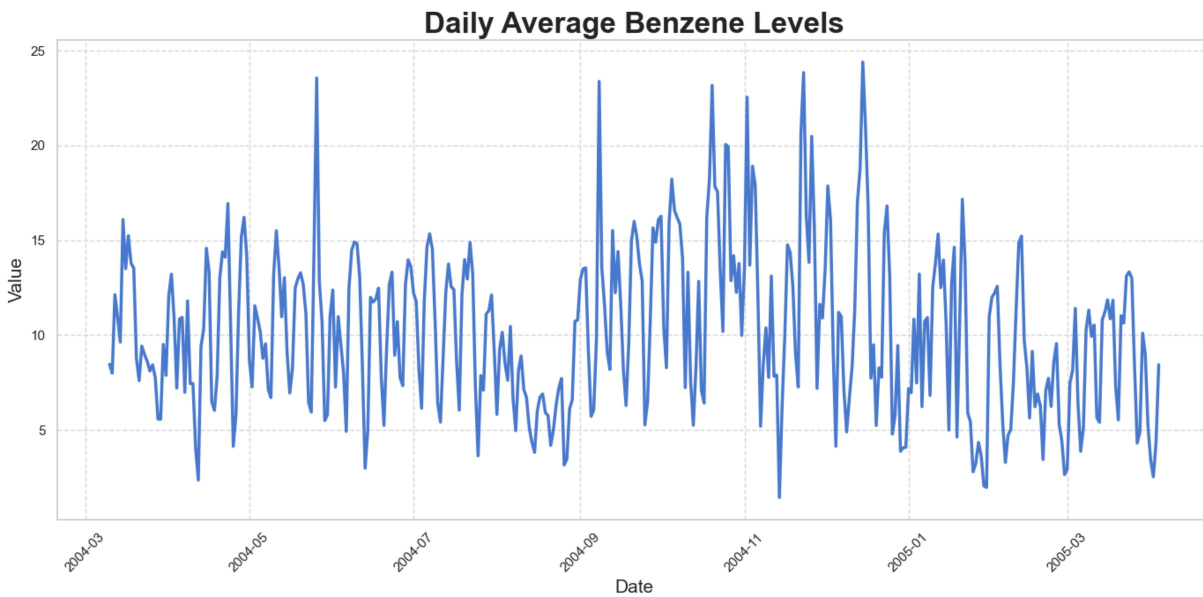
Pre-Processing

In [11]:
```python
df['date'] = pd.to_datetime(df['date'])
```

Exploratory Data Analysis

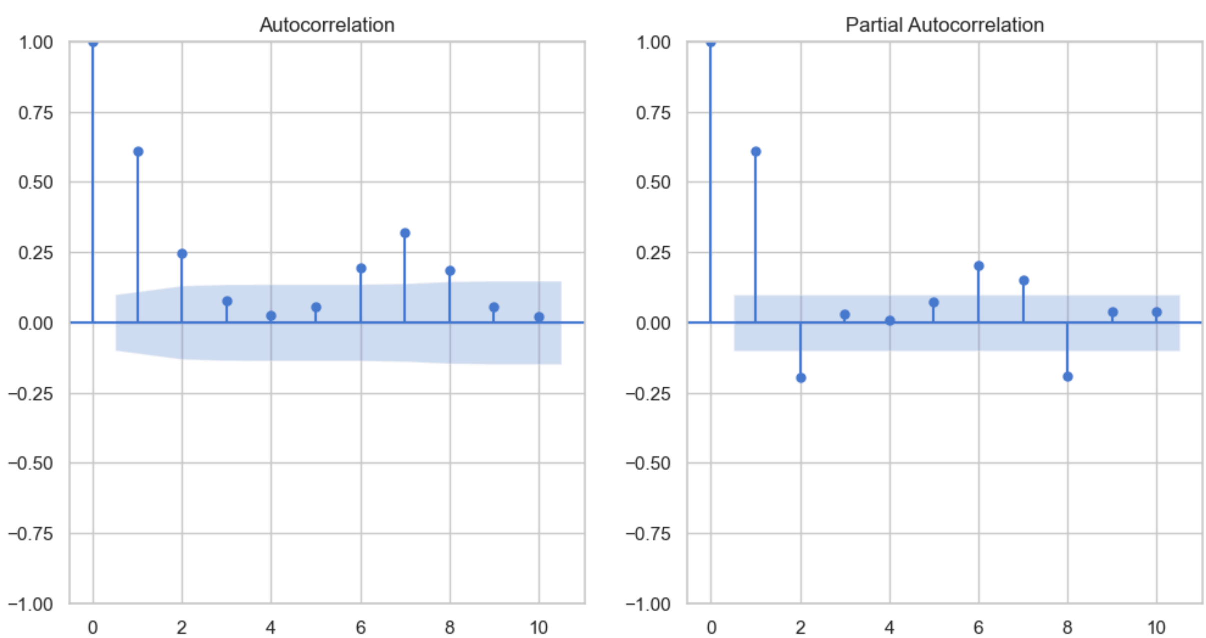
In [12]:
```python
# Time Series Plot
sns.set(style="whitegrid", palette="muted")
plt.figure(figsize=(14, 7))
sns.lineplot(x='date', y='daily_avg_benzene', data=df, linewidth=2.5)

plt.title('Daily Average Benzene Levels', fontsize=24, fontweight='bold')
plt.xlabel('Date', fontsize=15)
```

```
plt.ylabel('Value', fontsize=15)
plt.xticks(rotation=45)
plt.grid(True, linestyle='--', alpha=0.7)
plt.tight_layout()
```



Statistical Analysis

In [13]:
```
# ACF and PACF
plt.figure(figsize=(12, 6))
plt.subplot(121)
plot_acf(df['daily_avg_benzene'], lags=10, ax=plt.gca())
plt.subplot(122)
plot_pacf(df['daily_avg_benzene'], lags=10, ax=plt.gca())
plt.show()
```



In [14]:
```python
# ADF Test
adf_result = adfuller(df['daily_avg_benzene'].dropna())

print('ADF Statistic:', adf_result[0].round(4))
print('p-value:', adf_result[1].round(4))
print("Number of Observations Used: {}".format(adf_result[3]))
print("Critical Values:")
for key, value in adf_result[4].items():
    print("  {}: {:.4f}".format(key, value))
```

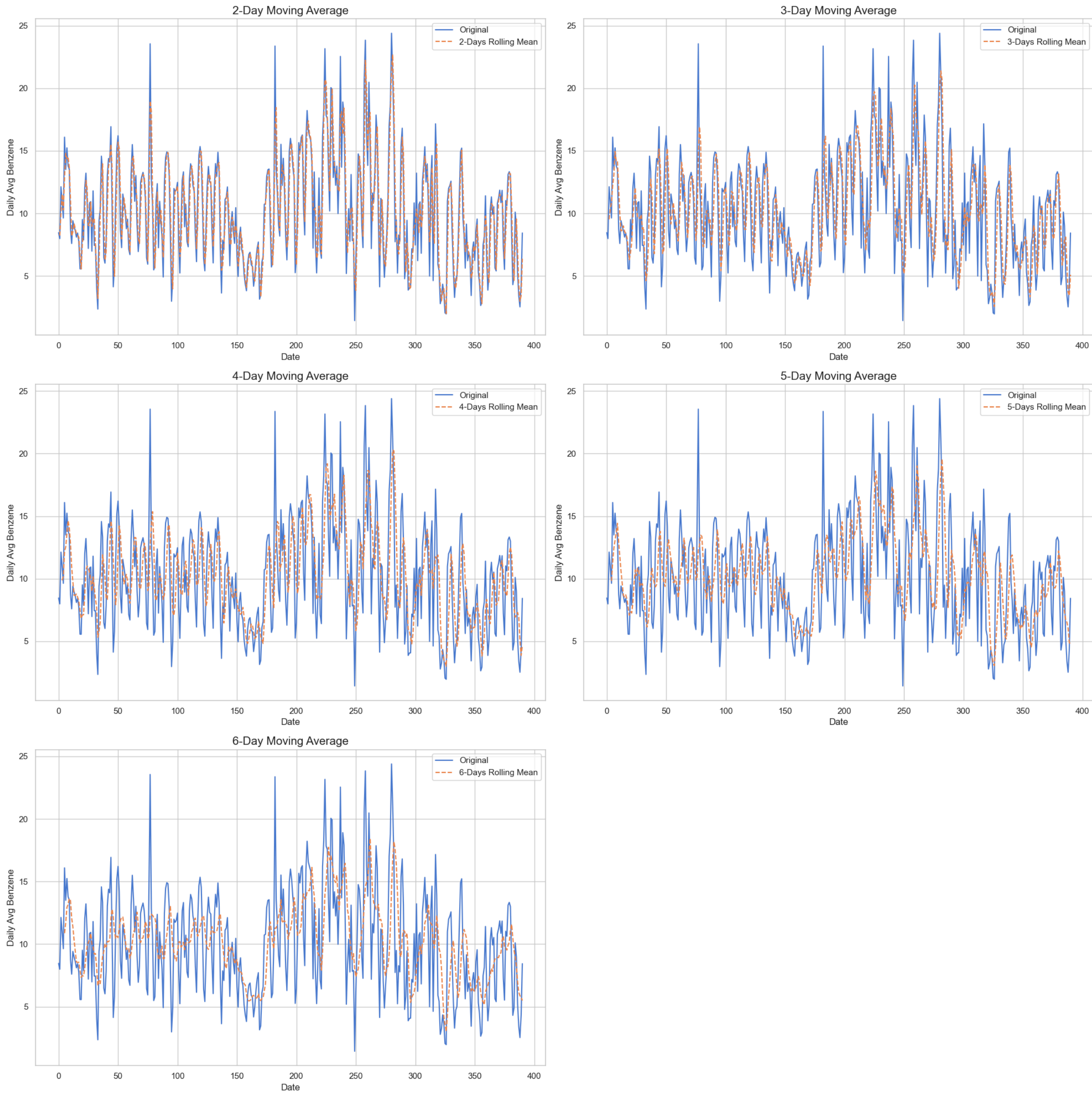
```
ADF Statistic: -4.0217
p-value: 0.0013
Number of Observations Used: 375
Critical Values:
  1%: -3.4479
  5%: -2.8693
  10%: -2.5709
```

In [15]:
```python
# KPSS Test
kpss_result = kpss(df['daily_avg_benzene'].dropna(), regression='c')

print('KPSS Statistic:', kpss_result[0].round(4))
print('p-value:', kpss_result[1].round(4))
print("Critical Values:")
for key, value in kpss_result[3].items():
    print("  {}: {:.4f}".format(key, value))
```

```
KPSS Statistic: 0.357
p-value: 0.0957
Critical Values:
  10%: 0.3470
  5%: 0.4630
  2.5%: 0.5740
  1%: 0.7390
```

Moving Average

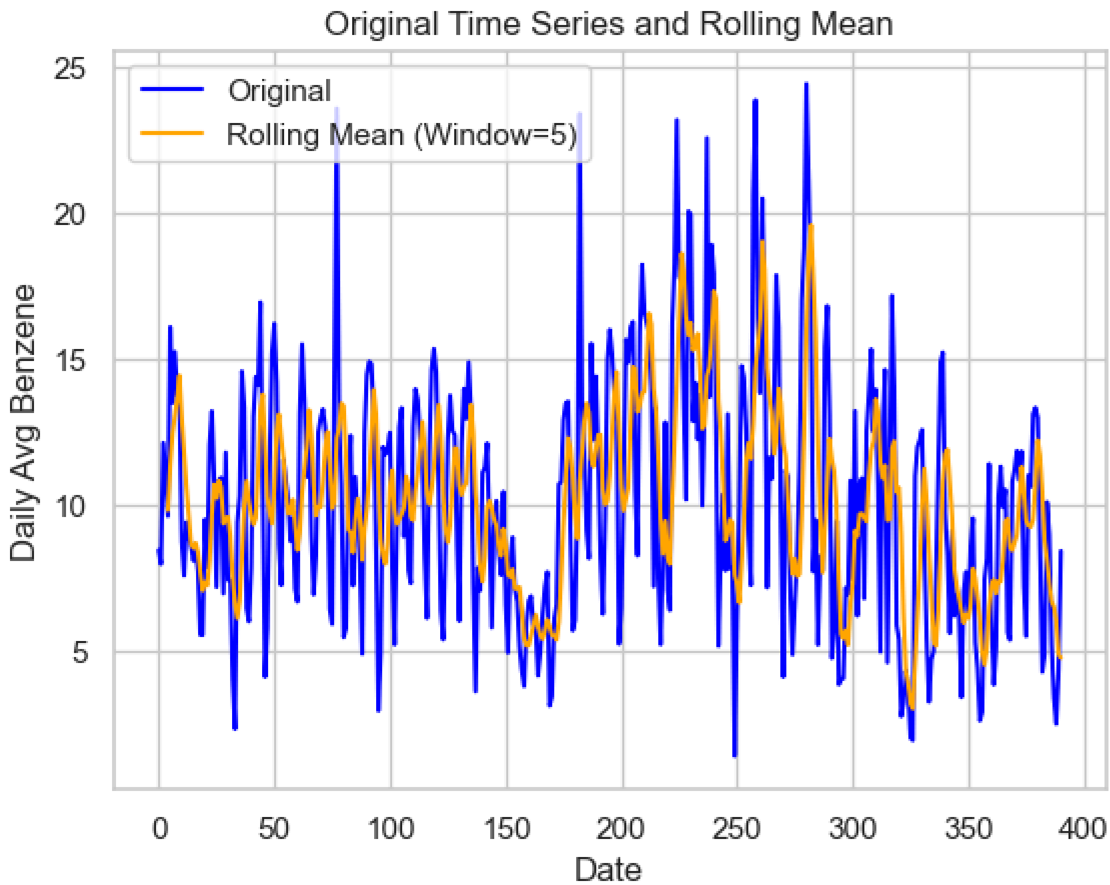
In [16]:
```python
plt.figure(figsize=(20, 20))

for i, window in enumerate([2, 3, 4, 5, 6]):
    moving_average = df['daily_avg_benzene'].rolling(window=window).mean()

    plt.subplot(3, 2, i + 1)
    plt.plot(df.index, df['daily_avg_benzene'], label='Original', linestyle=
    plt.plot(df.index, moving_average, label='{}-Days Rolling Mean'.format(w
    plt.xlabel("Date")
    plt.ylabel("Daily Avg Benzene")
    plt.title("{}-Day Moving Average".format(window), fontsize=15)
    plt.grid(True)
    plt.legend(loc='best')

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



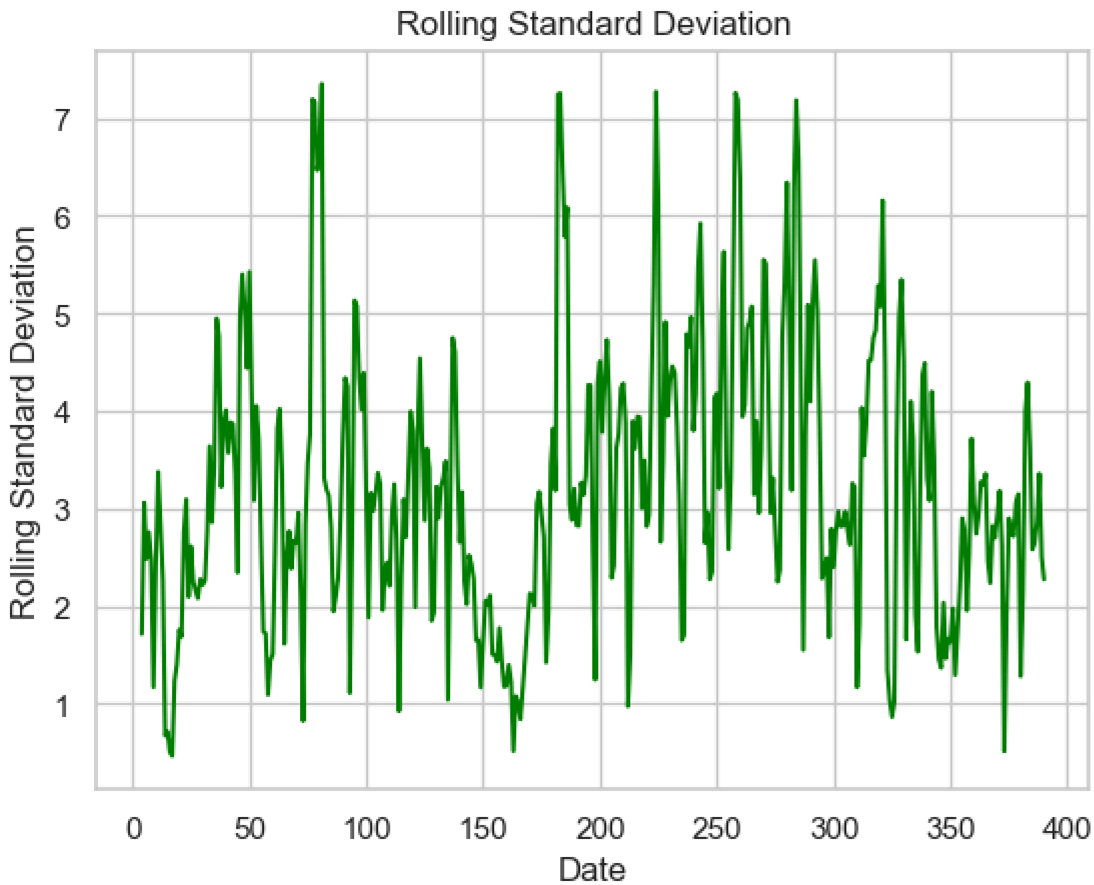
Rolling Statistics

In [17]:
```
rolling_mean = df['daily_avg_benzene'].rolling(window=5).mean()
rolling_std = df['daily_avg_benzene'].rolling(window=5).std()
```

In [18]:
```
# Original Time Series and Rolling Mean
plt.plot(df.index, df['daily_avg_benzene'], label='Original', color='blue')
plt.plot(df.index, rolling_mean, label='Rolling Mean (Window=5)', color='ora
plt.title('Original Time Series and Rolling Mean')
plt.xlabel('Date')
plt.ylabel('Daily Avg Benzene')
plt.legend(loc='best')
plt.grid(True)
plt.show()
```

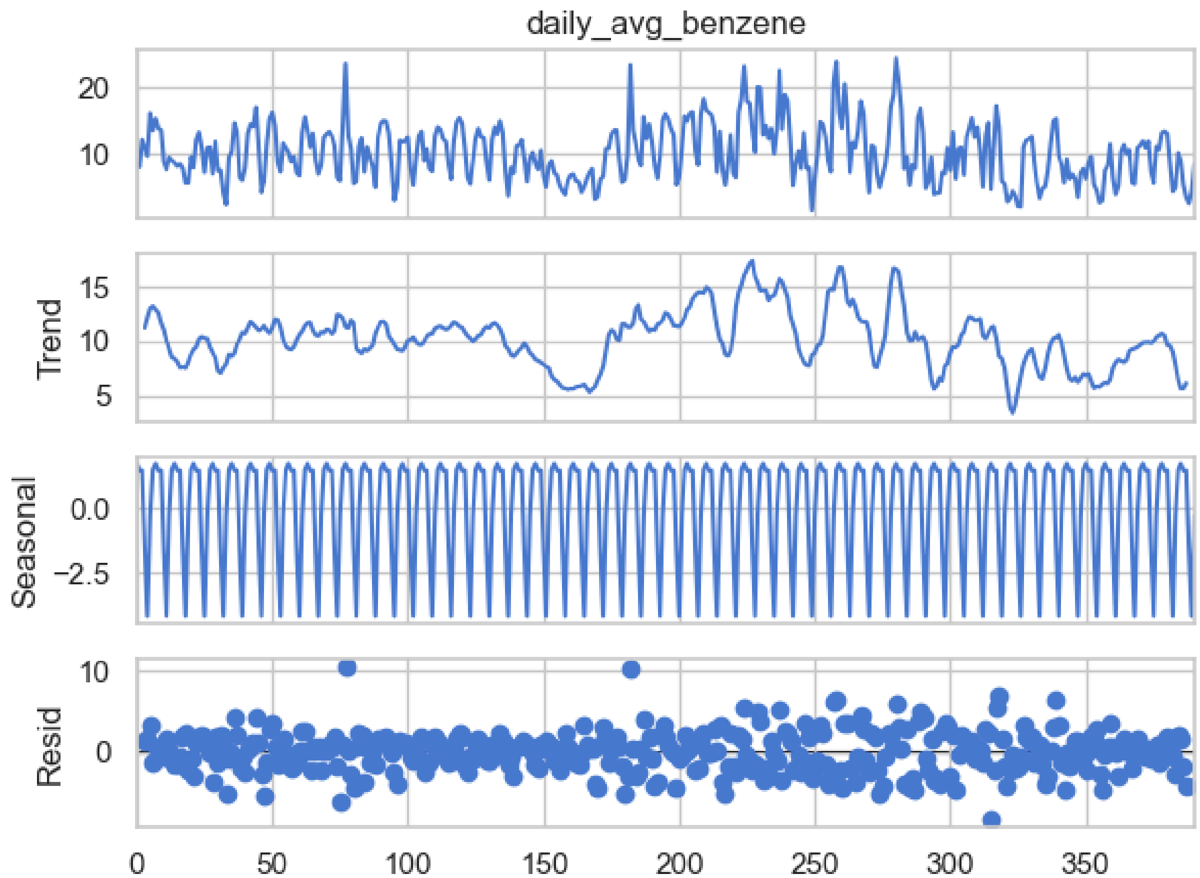


In [19]:
```
# Rolling Standard Deviation
plt.plot(df.index, rolling_std, label='Rolling Std Dev (Window=5)', color='g
plt.title('Rolling Standard Deviation')
plt.xlabel('Date')
plt.ylabel('Rolling Standard Deviation')
plt.show()
```



Decomposition

In [20]:
```
# Additive Decomposition
additive_decomposition = seasonal_decompose(df['daily_avg_benzene'], model='
additive_decomposition.plot()
plt.show()
```



Residuals of Decomposition

In [21]:
```
residuals = additive_decomposition.resid
```

In [22]:
```
# Dickey-Fuller Test
adf_test = adfuller(residuals.dropna(), autolag='AIC')

print("ADF Statistic: {:.4f}".format(adf_test[0]))
print("p-value: {:.4f}".format(adf_test[1]))
print("Number of Lags Used: {}".format(adf_test[2]))
print("Number of Observations Used: {}".format(adf_test[3]))
print("Critical Values:")
for key, value in adf_test[4].items():
    print("  {}: {:.4f}".format(key, value))
```

```
ADF Statistic: -8.5327
p-value: 0.0000
Number of Lags Used: 17
Number of Observations Used: 367
Critical Values:
  1%: -3.4483
  5%: -2.8694
  10%: -2.5710
```

In [23]:
```
# KPPS Test
kpss_test = kpss(residuals.dropna(), nlags='auto')
```

```python
print("KPSS Statistic: {:.4f}".format(kpss_test[0]))
print("p-value: {:.4f}".format(kpss_test[1]))
print("Lags Used: {}".format(kpss_test[2]))
print("Critical Values:")
for key, value in kpss_test[3].items():
    print("  {}: {:.4f}".format(key, value))
```

```
KPSS Statistic: 0.3624
p-value: 0.0934
Lags Used: 209
Critical Values:
  10%: 0.3470
  5%: 0.4630
  2.5%: 0.5740
  1%: 0.7390
```