

Assignment

Singrauli coal mines -

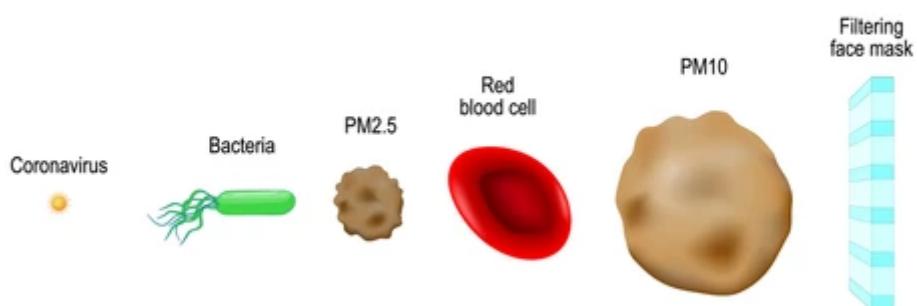


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The Singrauli Coalfield is located between latitudes $24^{\circ}12' N$ and $23^{\circ}47' N$. It is spread over nearly $2,200 \text{ km}^2$ (850 sq mi) but only a small part of the coalfield, around 220 km^2 (85 sq mi), has been identified as promising by the Geological Survey of India. The north-eastern part of the coalfield sits on a plateau with an altitude of 500 m above mean sea level, well above the lower plains of 280m altitude.

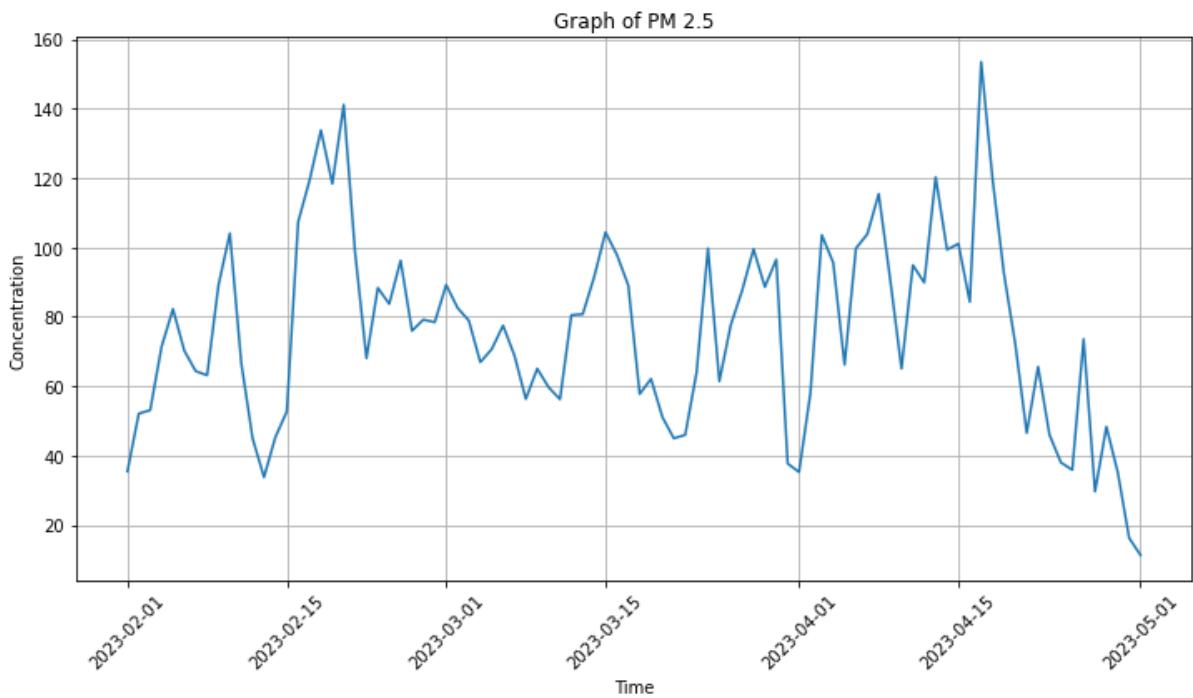
Particulate Matter 2.5 (PM2.5) :

Air pollution



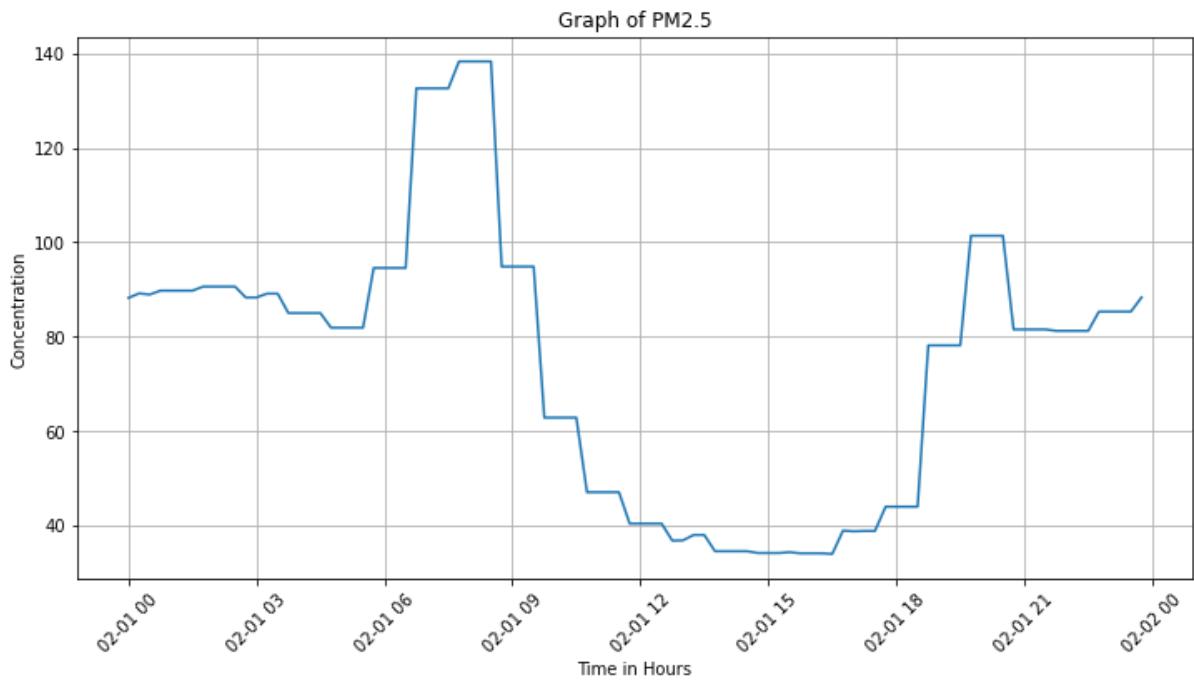
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- Opencast coal mines, a major source of airborne particulate matter (PM), is widespread in India
- PM_{2.5} can easily penetrate through the respiratory system to the deeper parts of the lung and therefore, it can cause the respiratory diseases
- Long exposure to PM_{2.5} can cause severe respiratory disorders like Bronchitis, Asthma etc.
- The Average Concentration of PM_{2.5} throughout 3 months from 1 Feb 2023 to 1 May 2023.

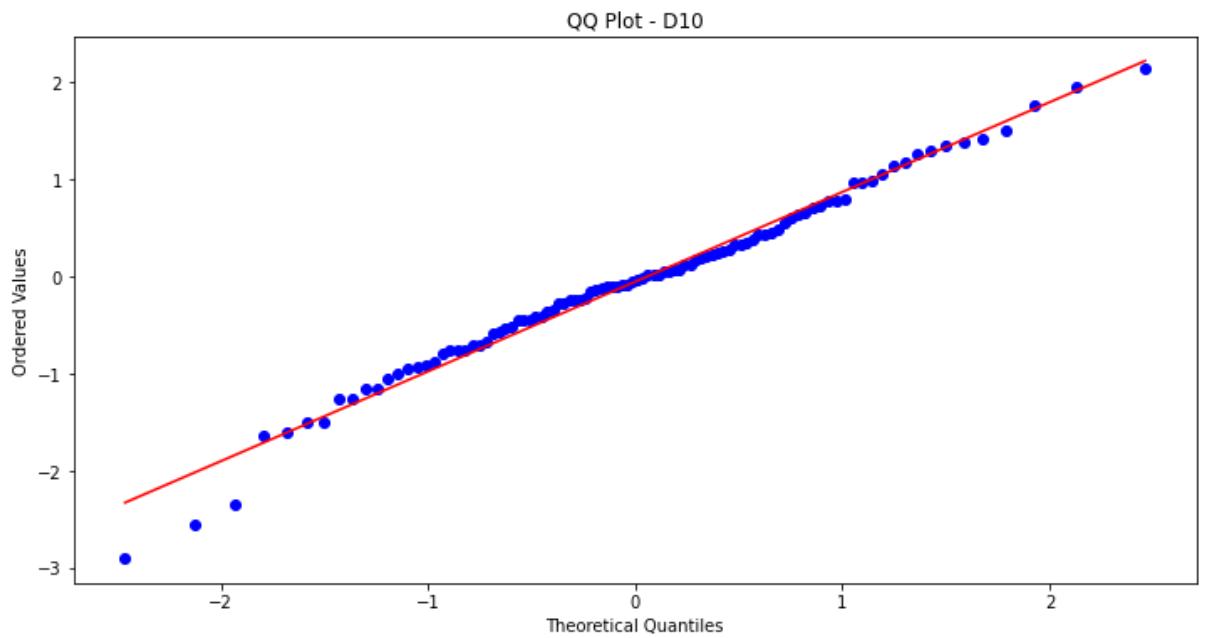


- Concentration at night is relatively higher than day because of less wind at night due to no warming of land .
- The Graph depicts the average concentration throughout the day .

➤ The Timely Average throughout 3 months



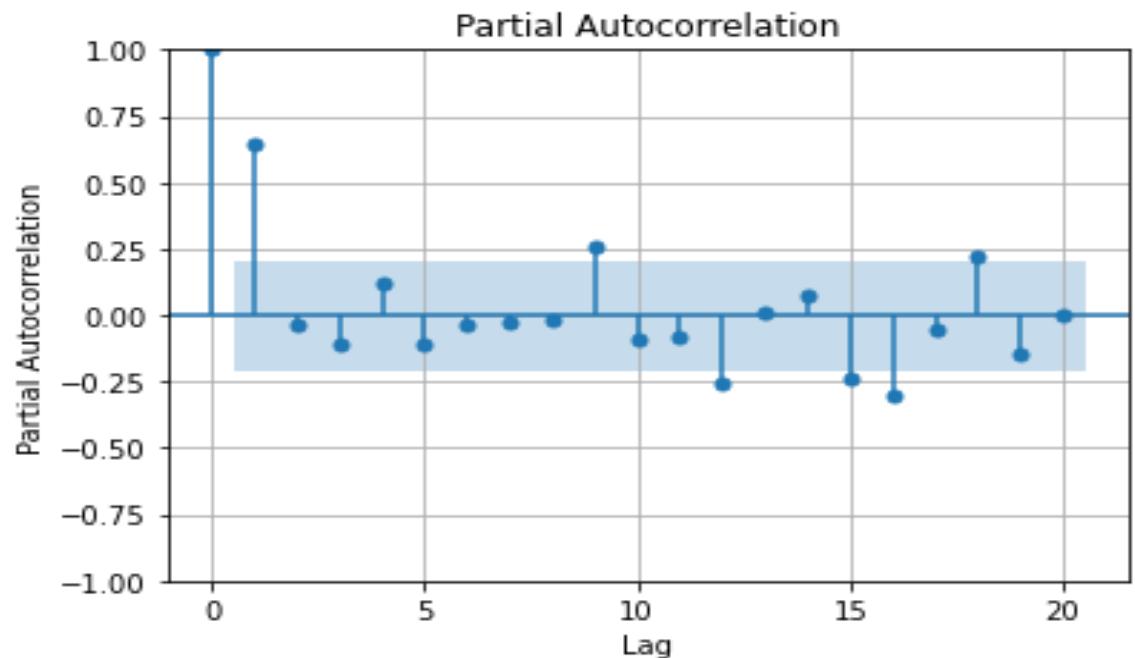
QQ Plot of PM2.5



- It seems that the graph follows a Straight Line , It means that the PM2.5 distribution is Normal Distribution .

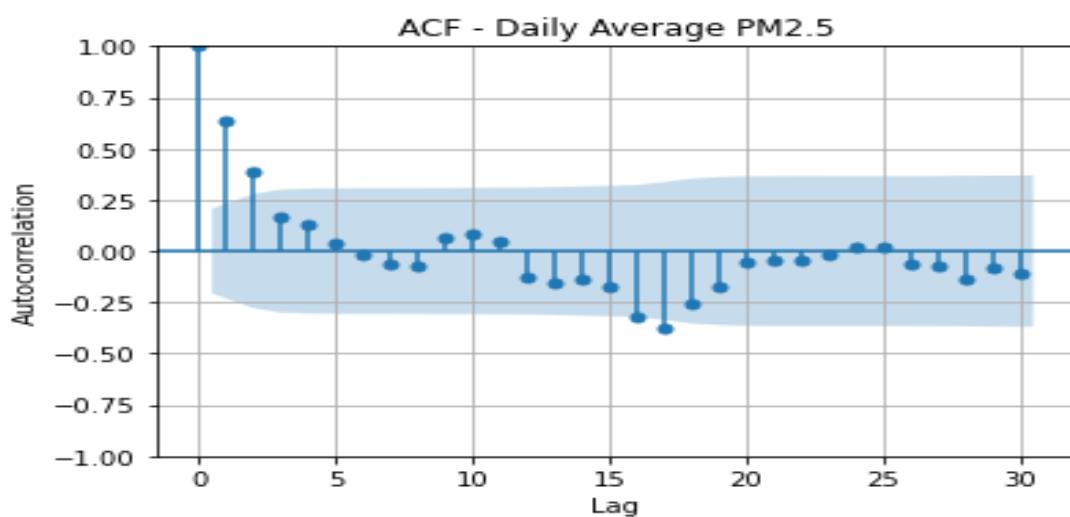
- According to WHO , the safe concentration of PM2.5 is 40 micrograms per cubic metre

➤Partial Auto-Correlation Function of PM2.5-



- PACF is not falling instantaneously may be ARMA
- There are several significant lines in the PACF chart of PM2.5.

➤ AutoCorrelation Function -



- ACF is not falling instantaneously , ARMA will be used to model PM2.5
 - It seem there is no observed pattern in ACF .
- Chance of Occuring respiratory disorder due to PM2.5 concentration.

\bar{X} = Observed Means

σ = Observed Standard Deviation

μ_0 = Standard Means

H_0 = Respiratory Disorder Occurs if $\mu=\mu_0$.

H' = Respiratory Disorder does not occur if $\mu \geq \mu_0$.

With 95% Confidence,

$$\bar{X}=75.59, \sigma=54.99, \mu_0=40$$

$$P(\bar{X} \geq c) = \text{Type-I error} \Rightarrow P(\bar{X} \geq c) = \alpha$$

$$\Rightarrow P((\bar{X} - \mu_0)/\sigma \geq (c - \mu_0)/\sigma)$$

$$\Rightarrow P(Z \geq (c - \mu_0)/\sigma) = \alpha$$

$$\Rightarrow P(Z \geq (c - \mu_0)/\sigma) = 0.05$$

$$\Rightarrow P(Z \geq (c - \mu_0)/\sigma) = P(1.28)$$

$$\Rightarrow (c - \mu_0)/\sigma = 1.28$$

$$\Rightarrow c = 110.38$$

$\bar{X} < c$, we can't reject H_0 in favour of H'

β =Type II Error

$$P(\bar{X} < \mu_0 + Z\alpha\sigma; \mu \geq \mu_0) = \beta$$

$$\Rightarrow P((\bar{X} - \mu')/\sigma < (\mu_0 + Z\alpha\sigma - \mu')/\sigma; \mu \geq \mu_0) = \beta$$

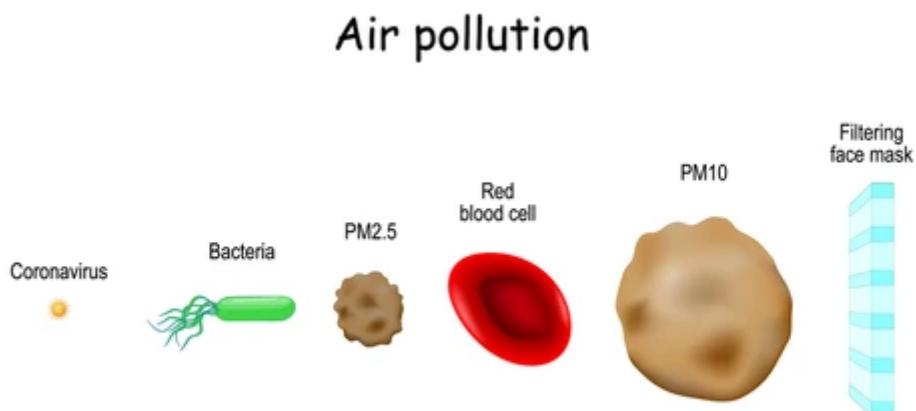
$$\Rightarrow P(Z < (\mu_0 + Z\alpha\sigma - \mu')/\sigma; \mu \geq \mu_0) = \beta \quad \therefore \mu = 75.59$$

$$\Rightarrow P(Z < .63) = \beta$$

$$\Rightarrow \beta = .7356$$

Power of test = $1 - \beta \Rightarrow .2644$

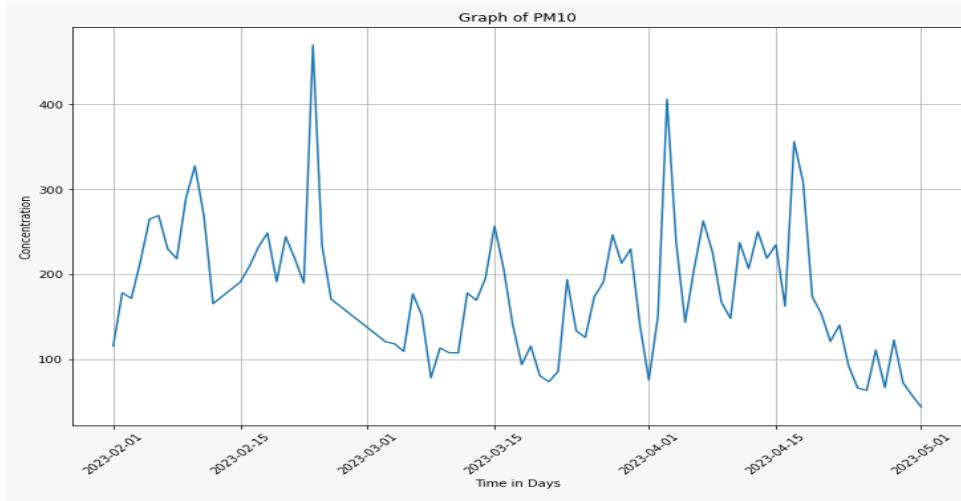
Particulate Matter 10 (PM10)



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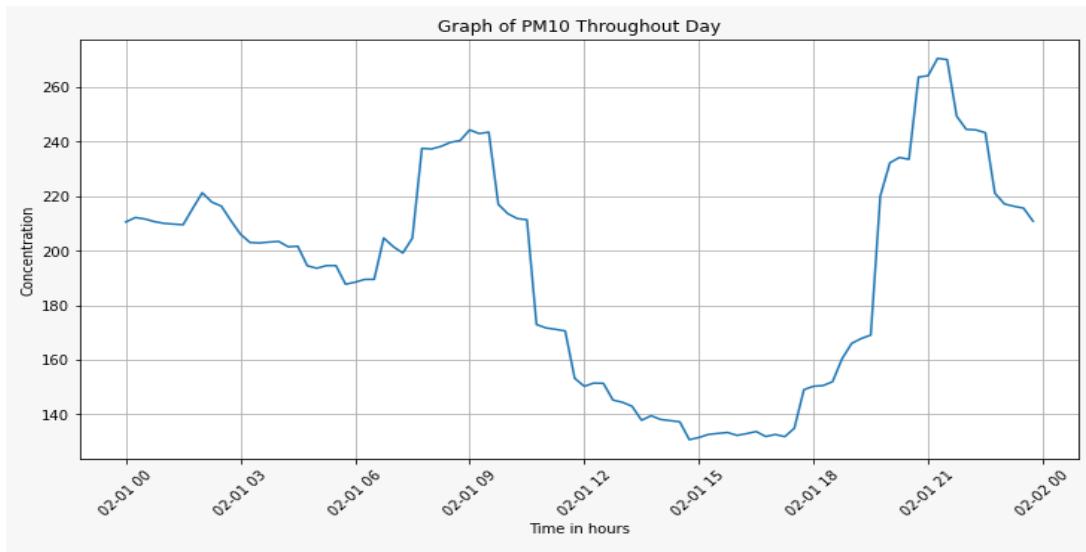
- PM10 (Particulate Matter 10) refers to inhalable particles with a diameter of 10 micrometres or smaller
- Long exposure to PM10 can cause severe respiratory disorders like Bronchitis, Asthma etc.

- The Average Concentration of PM_{2.5} throughout 3 months from 1 Feb 2023 to 1 May 2023 is given below



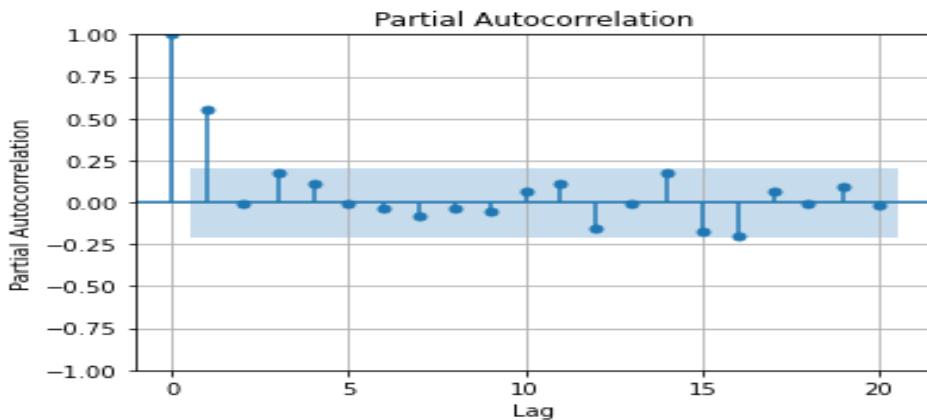
- The Monthly average graph shows that PM10 concentration reached its peak between 15 feb and 3 March.
- The Monthly Average Data of PM10 is not trending and seems to be stationary.
- Hence ,It is not Suitable for ARIMA Model.

- The Below Graph shows that Average of PM10 concentration at a particular time throughout 3 months



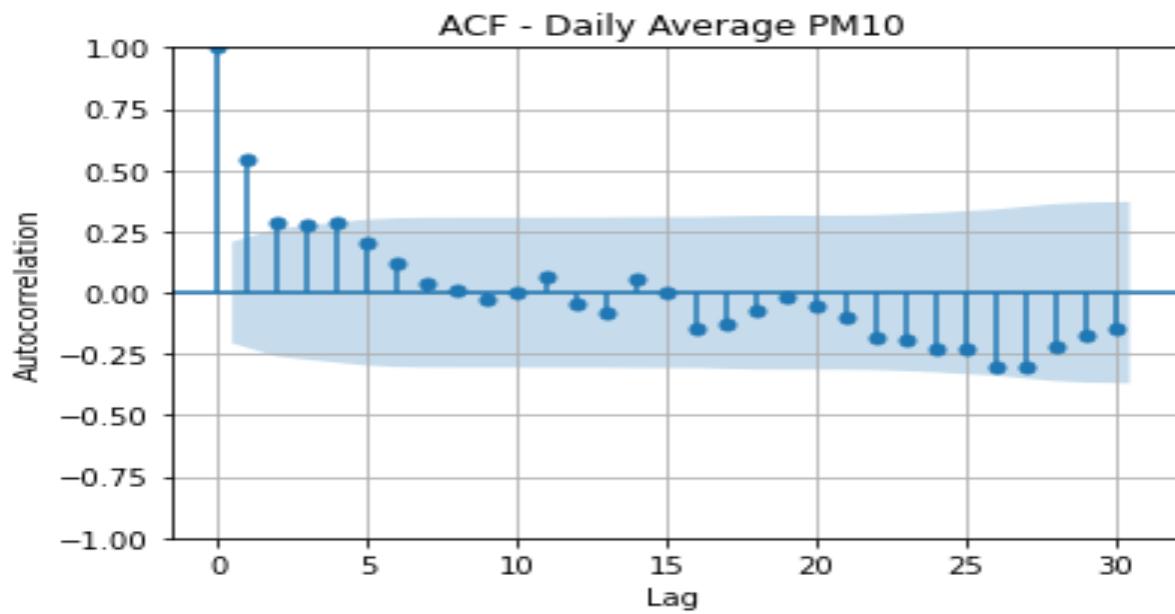
- The Graph reaches its peak in day time around 7 am to 9am which may be the most probable time for open pit blasting and at night time it reaches its peak around 9pm.
- The Graph reaches its lowest value around evening time i.e around 4pm to 5pm may be due to reduced mining activities in the evening .

➤ Partial ACF of PM10-



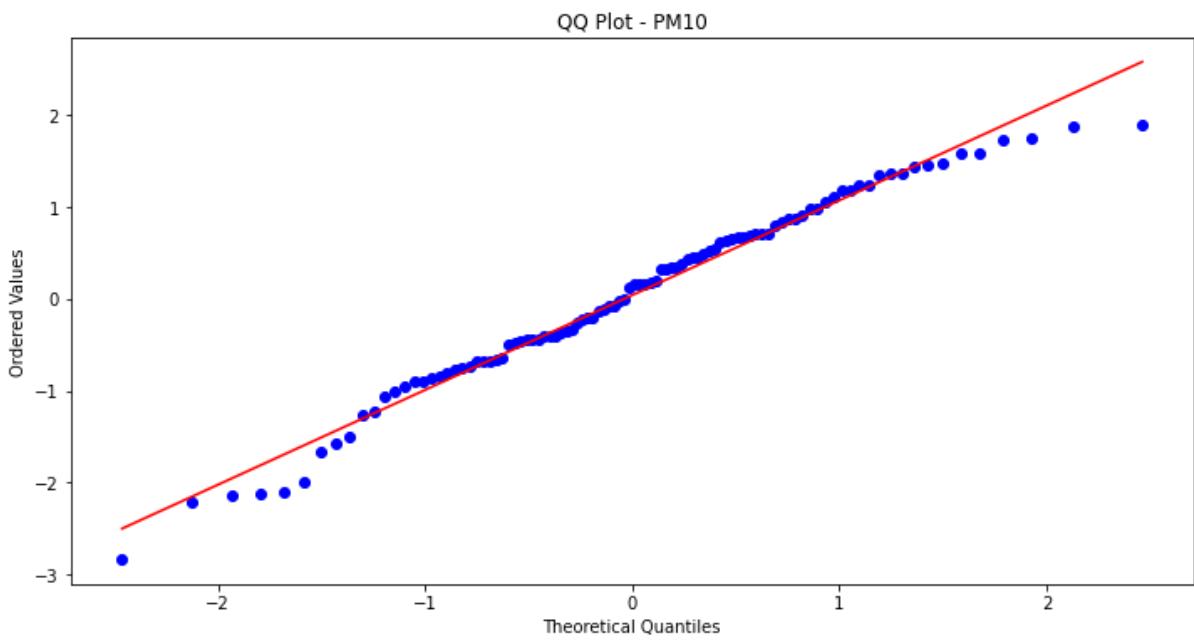
- PACF is not falling instantly may be ARMA will be used

➤ACF of PM10-



- ACF is not falling instantly and has 3 significant peaks ARMA Will be used to model PM10

➤QQ-Plot of PM10

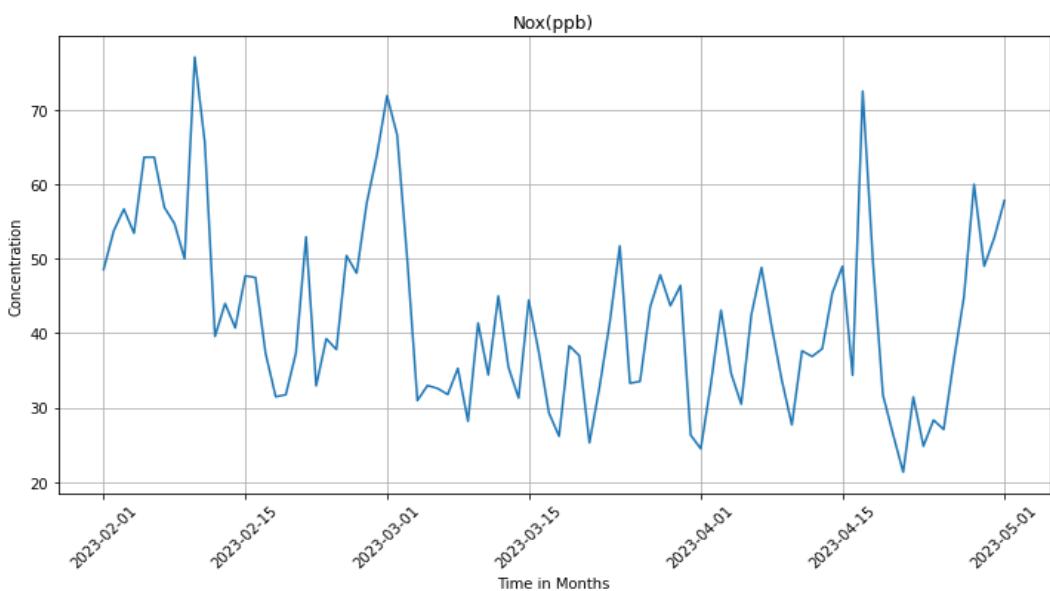


- The QQ plot of PM10 seems to be following a straight line . We can infer that Daily average of PM10 concentration is a normal distribution.

NOx(ppb)

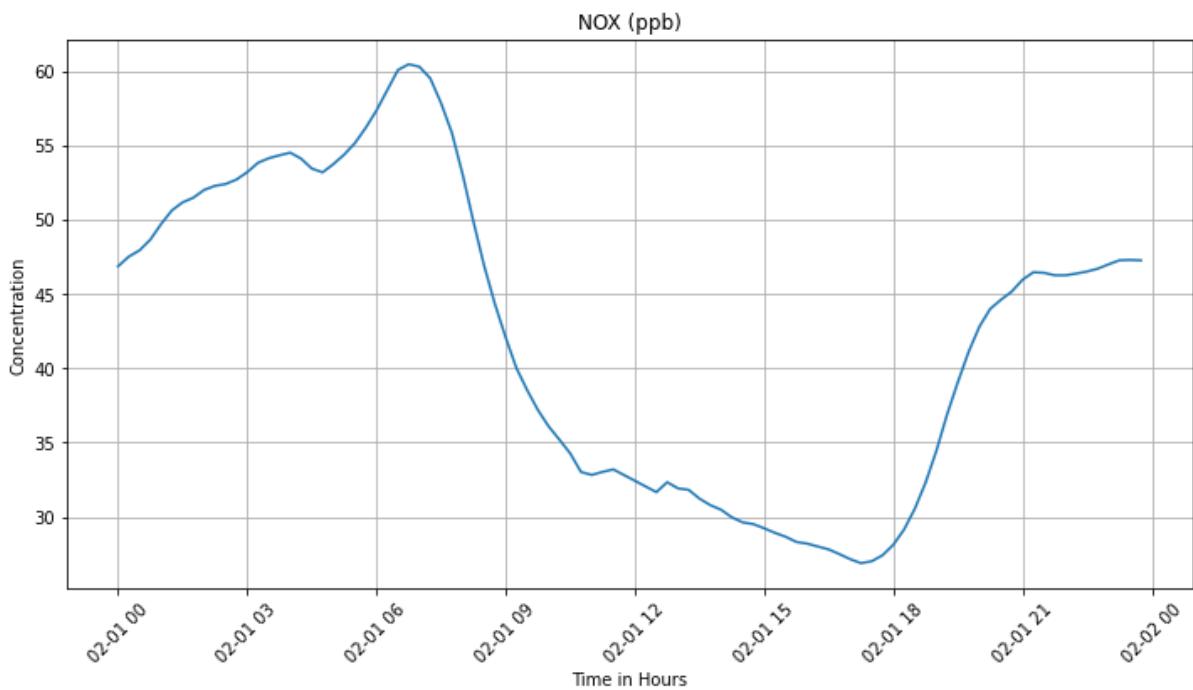


- NOx emissions contribute to the formation of acid rain when they react with other pollutants in the atmosphere
 - NOx emissions from coal mining operations contribute to air pollution. When released into the atmosphere, NOx reacts with other compounds to form smog, leading to poor air quality.
- The Average Concentration of PM2.5 throughout 3 months from 1 Feb 2023 to 1 May 2023 is given below

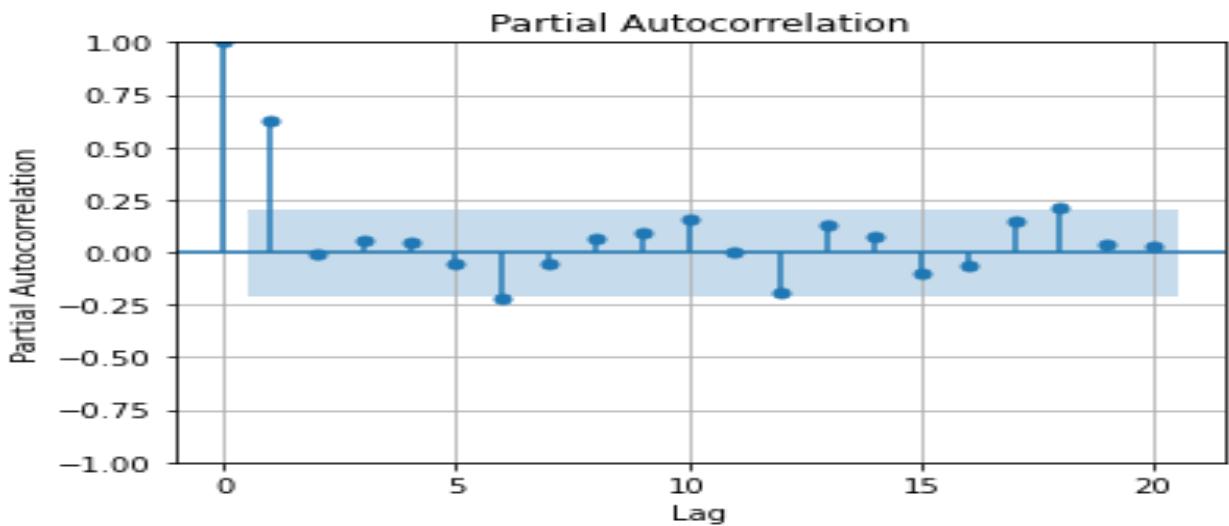


- The Daily Average Graph of NOx reaches its peak on 10 February with $77.112 \mu\text{g}/\text{m}^3$ average concentration
- The Daily Average Graph of NOx reaches its bottom on 21 April with $21.33 \mu\text{g}/\text{m}^3$ average concentration.
- The Graph above is not trending and no seasonality seems to be noticed.

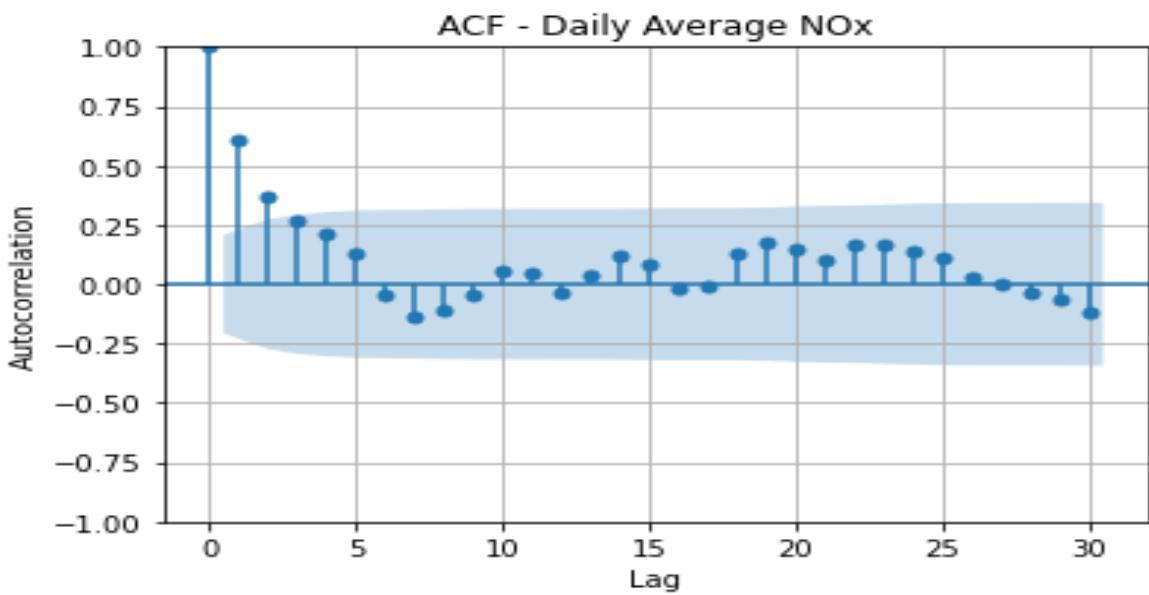
➤ The Timely Average throughout 3 months



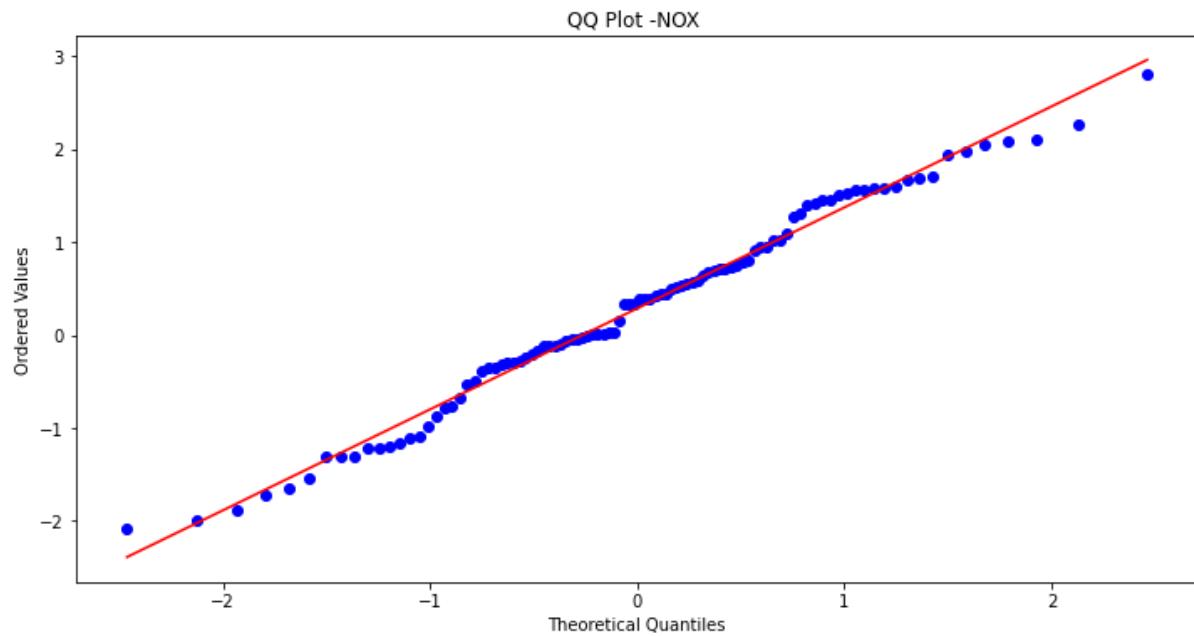
- The Minimum Concentration of NOx is around 5:15 pm in the evening .
- ➤Partial ACF of NOx -



➤ACF of NOx

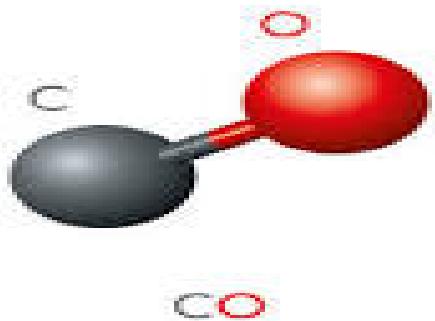


➤QQ-Plot of NOx -



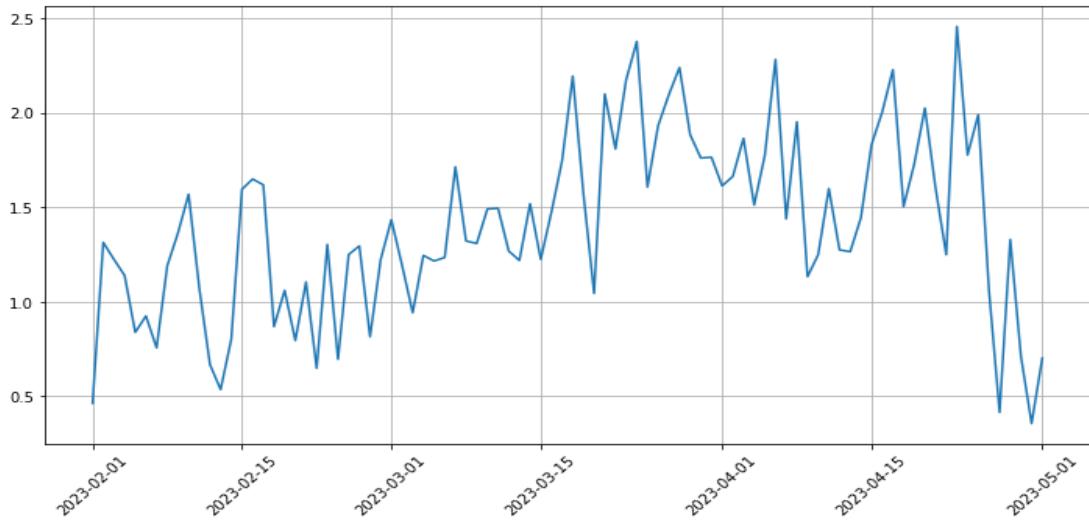
- The QQ plot of NOx does not seem to be following a straight line . We can infer that Daily average of NOx concentration is not a normal distribution.

CO (mg/m³)

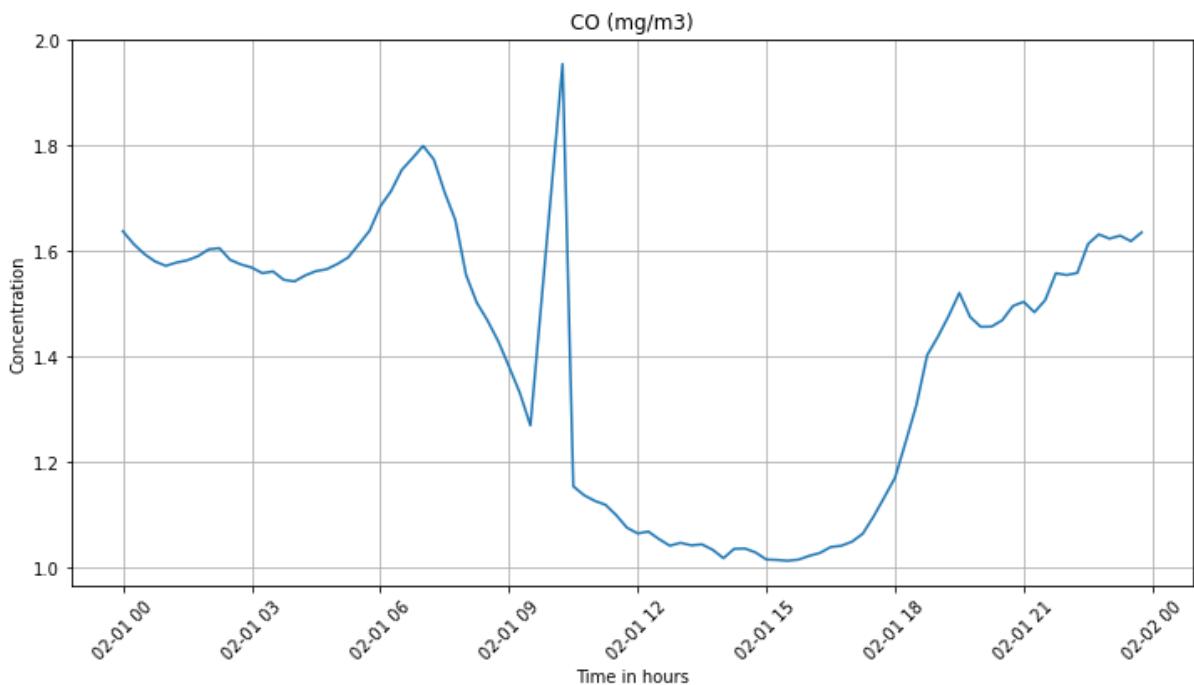


- CO is colourless, odourless, and tasteless, making it difficult to detect without proper monitoring equipment.
- Inhalation of high levels of CO can lead to carbon monoxide poisoning. CO is a toxic gas that can bind to haemoglobin in the bloodstream, reducing its ability to carry oxygen.

➤ The Average Concentration of PM2.5 throughout 3 months from 1 Feb 2023 to 1 May 2023 is given below

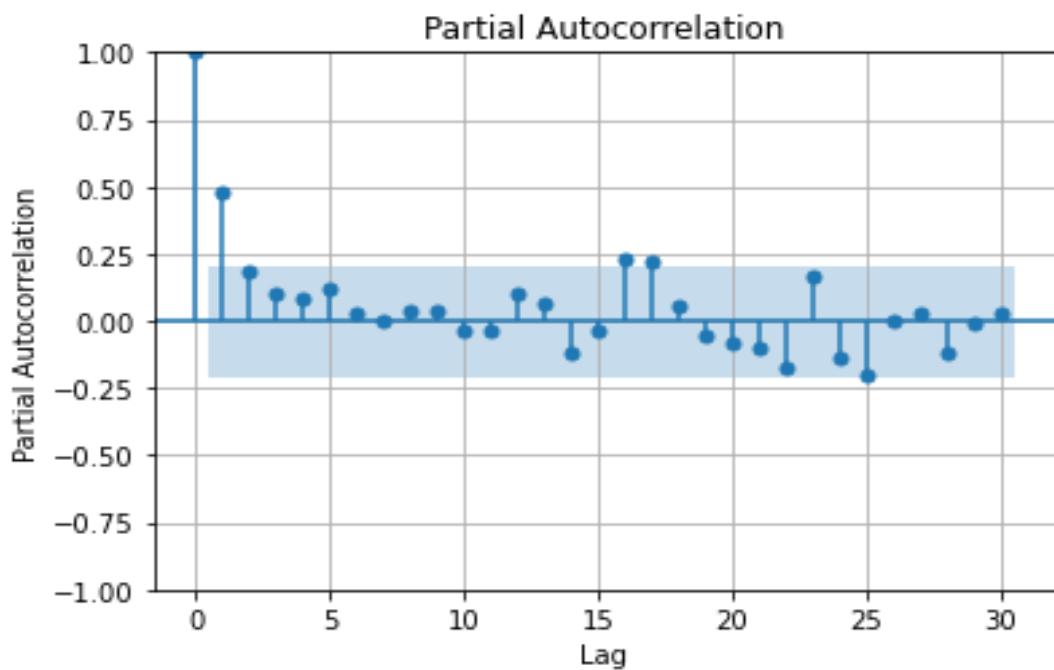


- The Daily Average Graph of CO reaches its peak on 23 April with 2.5 mg/m^3 average concentration
 - The Daily Average Graph of CO reaches its bottom on 30 April with $.35 \text{ mg/m}^3$ average concentration
 - The Graph above is not trending and no seasonality seems to be noticed.
- The Timely Average throughout 3 months

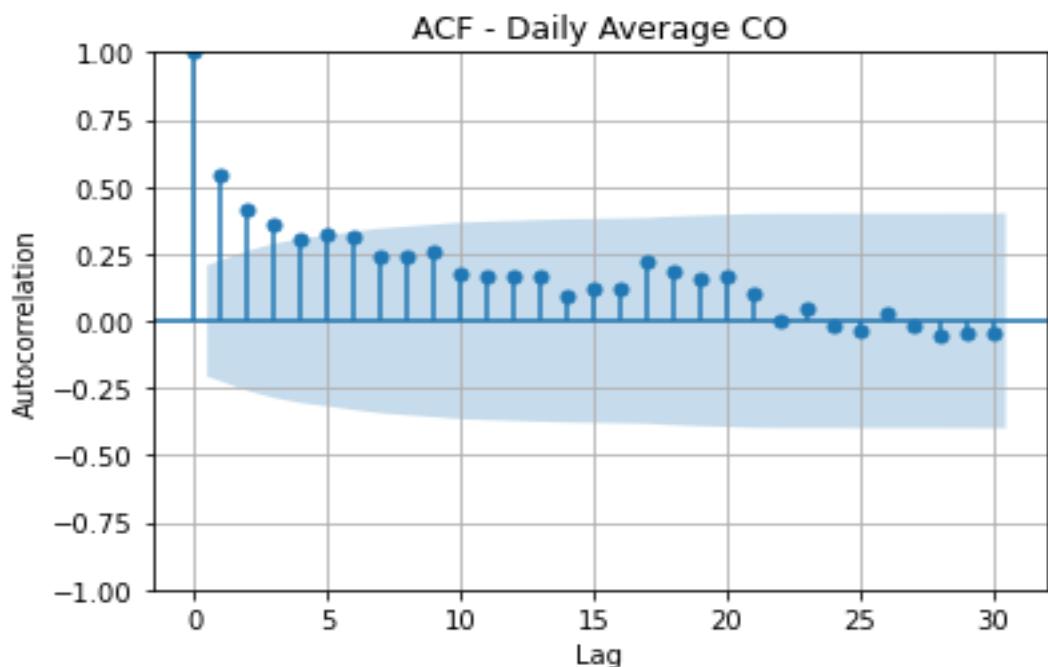


- The graph of CO rises around 7:00 am with 1.7mg/m³ in the daytime which we expect the most probable time for Open pit Blasting
- The Maximum Concentration of CO is around 10:15 am in the daytime
- We are ignoring the outlier with an excuse of a machinery mistake.
- The Minimum Concentration of CO is around 3:15 pm in the afternoon .

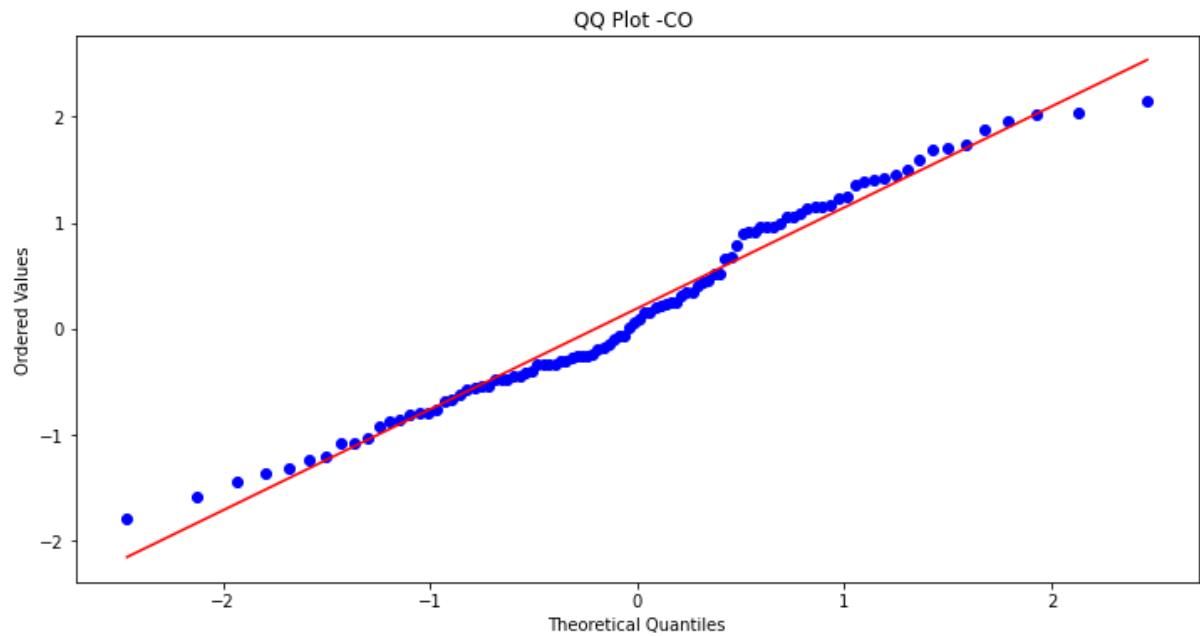
➤Partial ACF of CO -



➤ ACF of CO -



➤QQ- Plot of CO -



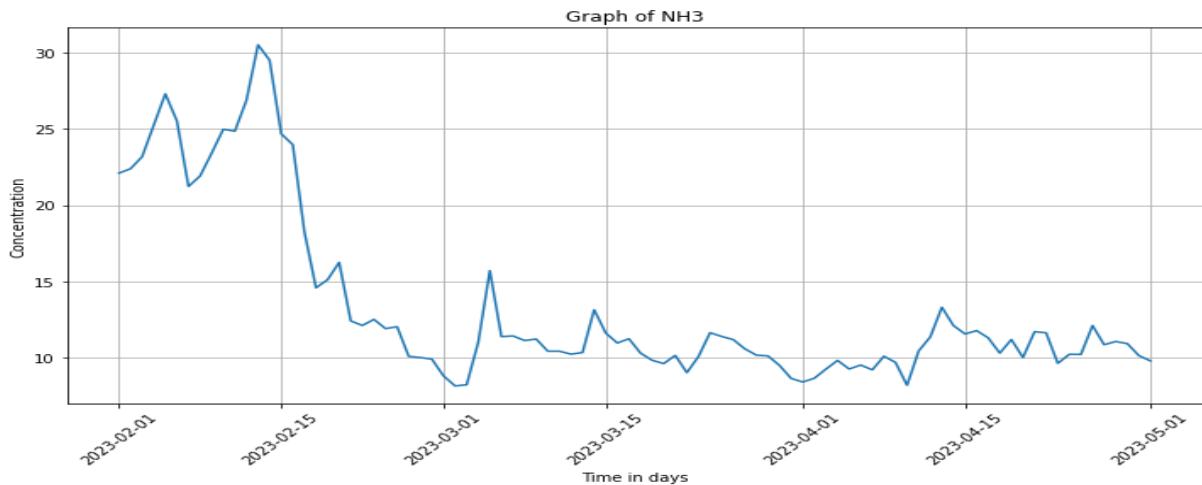
- The QQ plot of CO does not seem to be following a straight line. We can infer that Daily average of CO concentration is not a normal distribution.

NH₃ ($\mu\text{g}/\text{m}^3$)

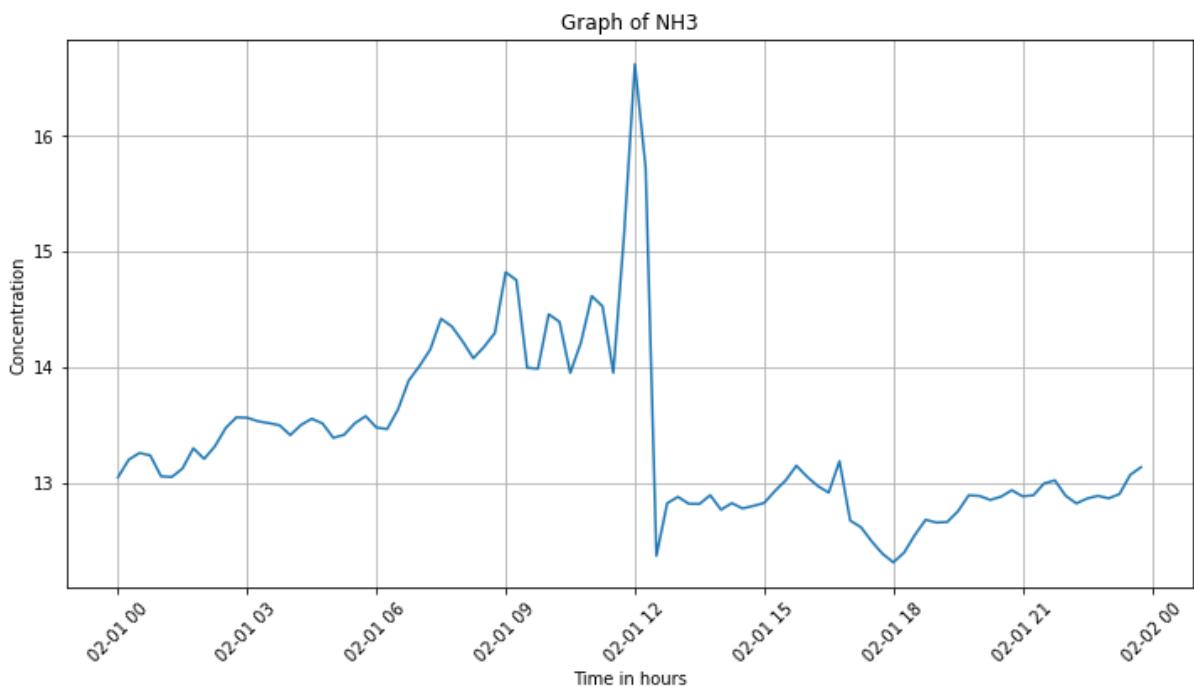


- NH₃ is a respiratory irritant and can cause irritation to the eyes, nose, throat, and respiratory system. Prolonged exposure to high levels of NH₃ can lead to respiratory symptoms such as coughing, wheezing, and shortness of breath.

- NH₃ can react with metals and cause corrosion in equipment and infrastructure within coal mining facilities
 - The Daily Average Concentration of NH₃ throughout 3 months from 1 Feb 2023 to 1 May 2023 is given below

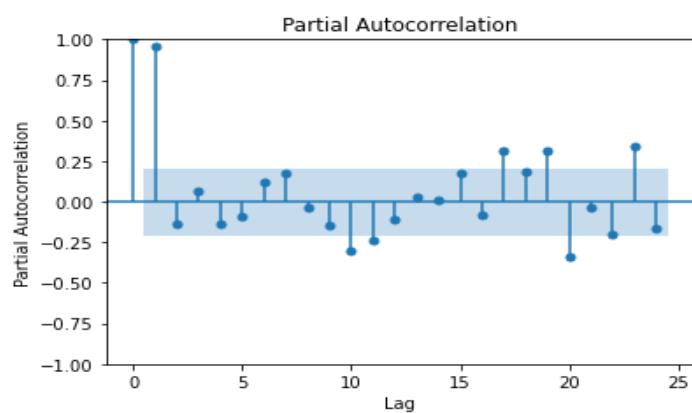


- The Daily Average Graph of NH₃ reaches its peak on 13 February with 30.52 $\mu\text{g}/\text{m}^3$ average concentration
- The Daily Average Graph of NH₃ reaches its bottom on 2 March with 8.13 $\mu\text{g}/\text{m}^3$ average concentration
 - The Correlation of NH₃ with most of the Gases in the Dataset is Negative.

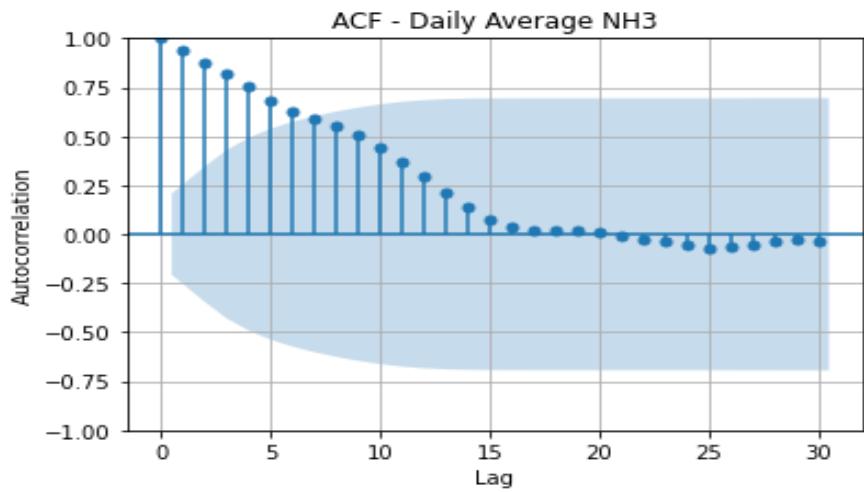


- The graph of NH3 rises around 7:15 am with $14.059 \mu\text{g}/\text{m}^3$ in the daytime which we expect to be the most probable time for Open pit Blasting.
- The Maximum Concentration of NH3 is around 12:15 pm with $15.639 \mu\text{g}/\text{m}^3$ in the daytime.
- The Minimum Concentration of NH3 is around 6:00 pm with $12.277 \mu\text{g}/\text{m}^3$ in the daytime.

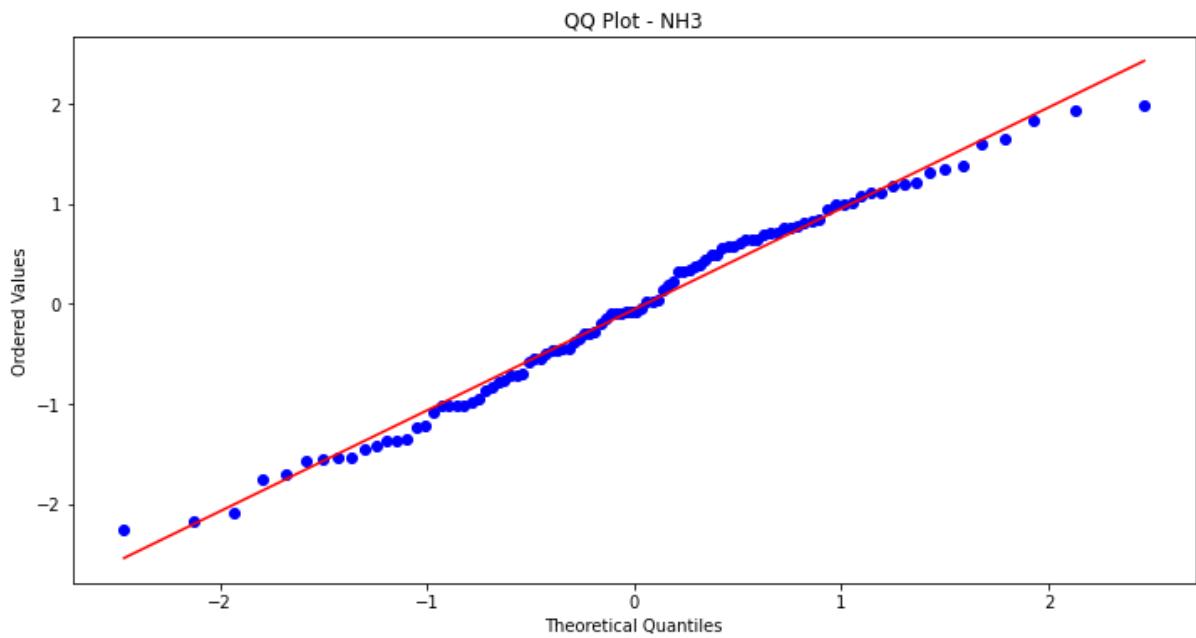
➤ Partial ACF of NH3-



➤ ACF of NH3 -

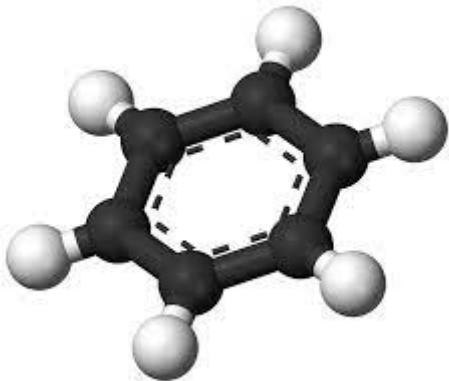


➤ QQ-Plot of NH3-



- The QQ plot of NH3 does not seem to be following a straight line . We can infer that Daily average of NH3 concentration is not a normal distribution.

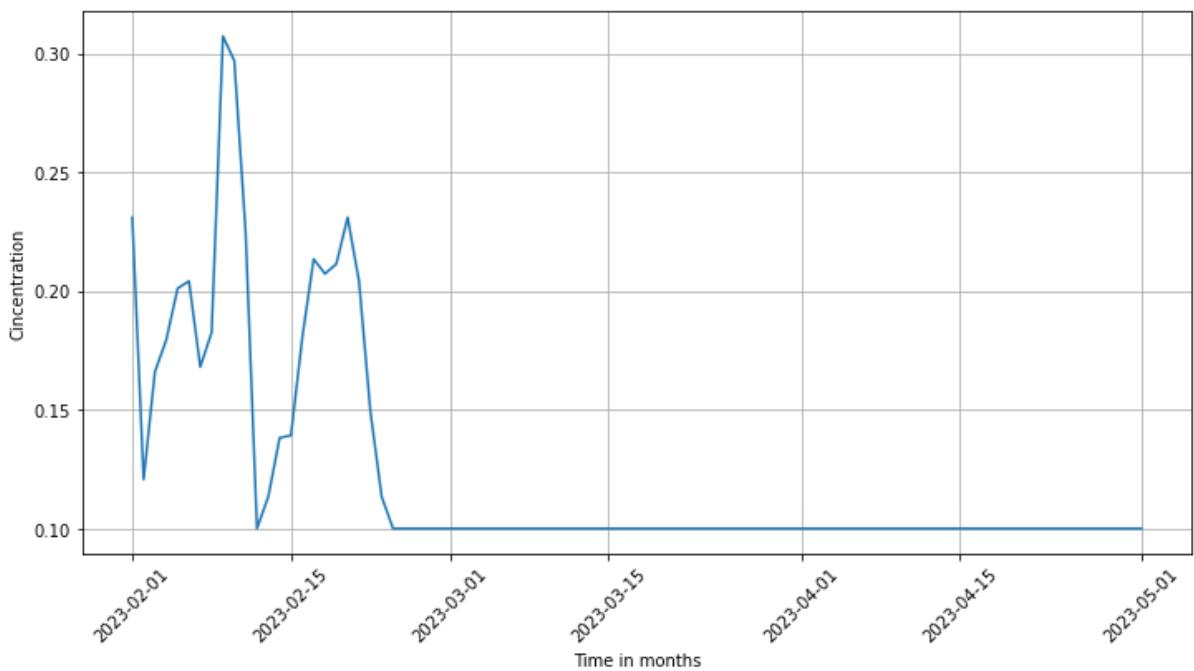
Benzene



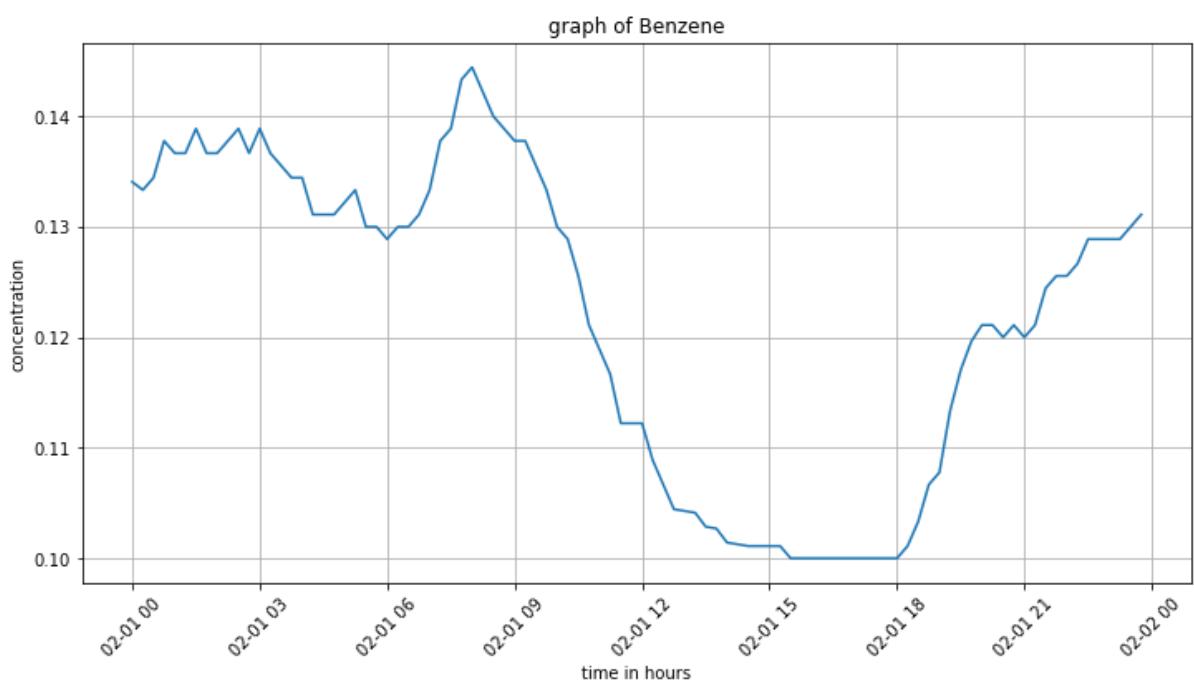
- Benzene is a known human carcinogen and long-term exposure to high levels of benzene can increase the risk of developing various types of cancer, including leukaemia and other blood-related cancers

 - Benzene can react with other pollutants in the atmosphere, contributing to the formation of ground-level ozone and smog

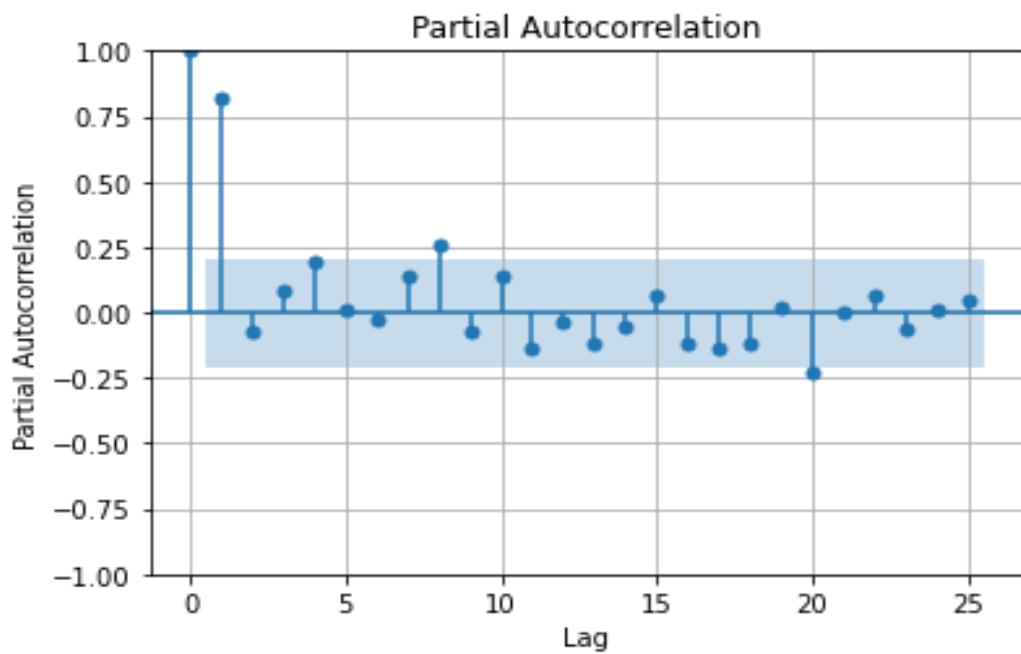
 - Benzene is a Volatile Organic Compound (VOCs)
-
- The Daily Average Concentration of Benzene throughout 3 months from 1 Feb 2023 to 1 May 2023 is given below



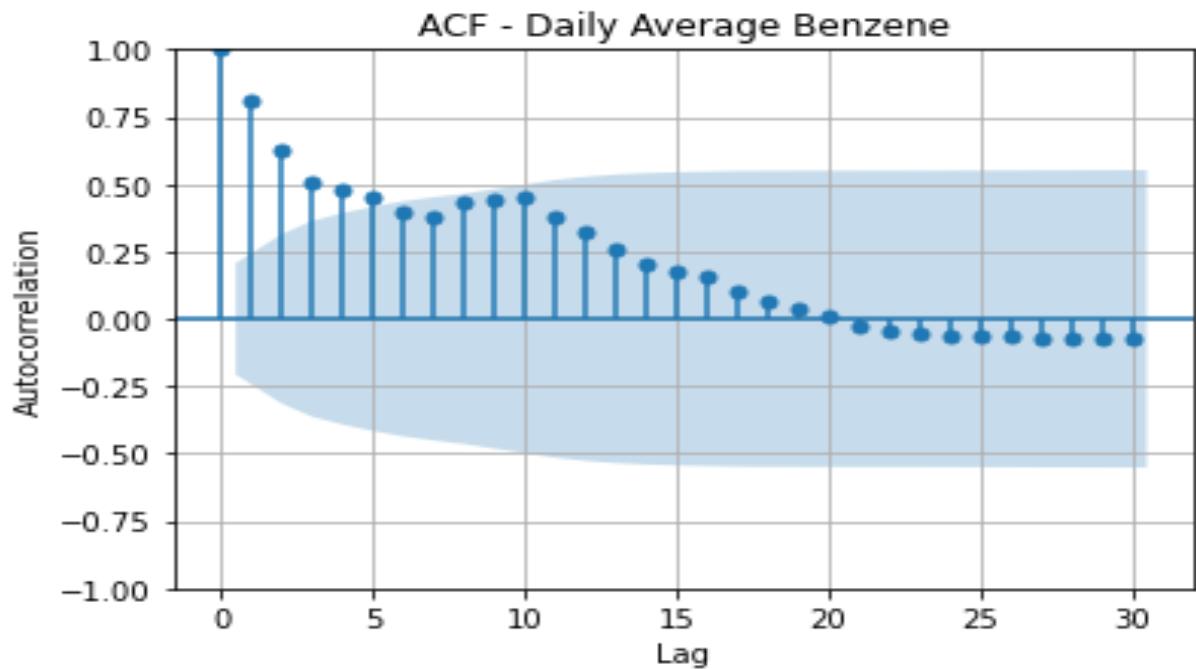
➤The Timely Average throughout 3 months



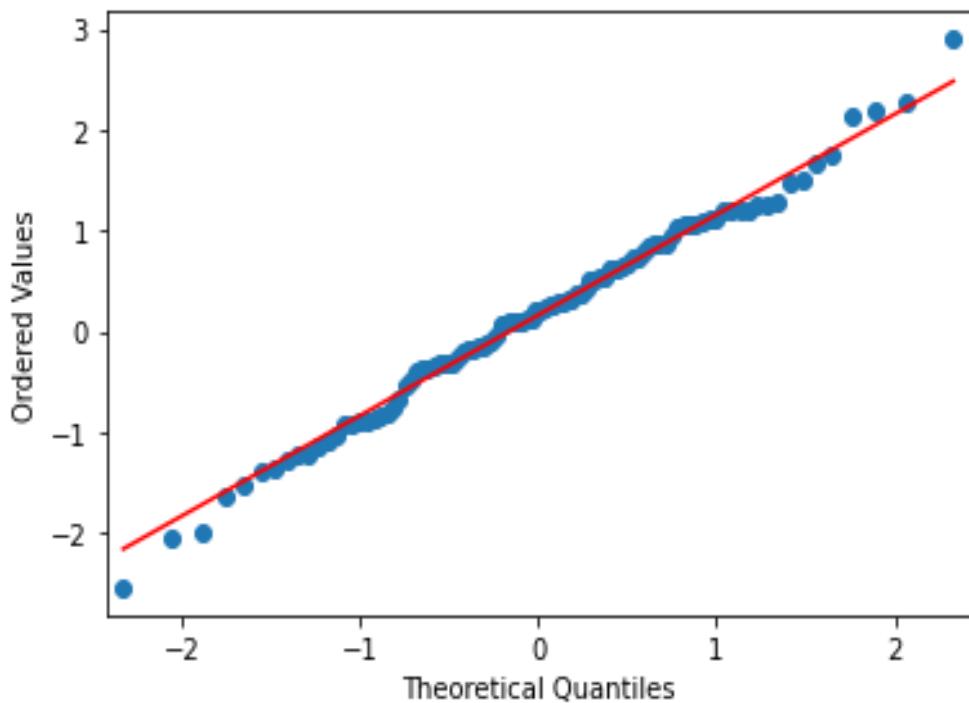
➤Partial ACF of Benzene-



➤ ACF of Benzene -



➤ QQ-Plot of Benzene-



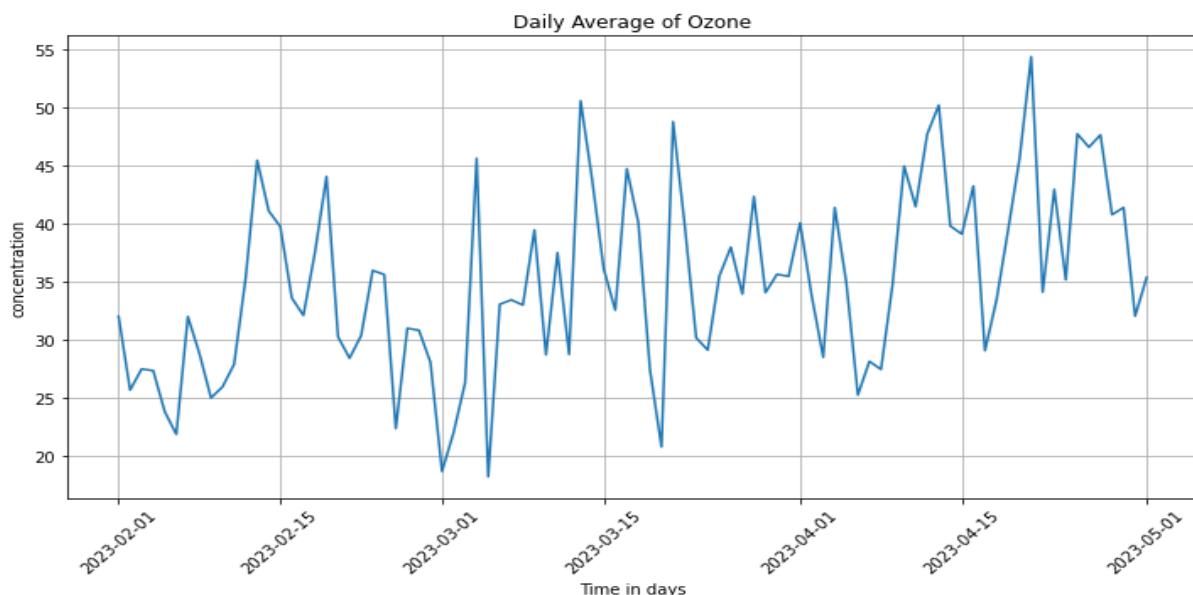
- The QQ plot of Benzene seems to be following a straight line . We can infer that the Daily average of Benzene concentration is a normal distribution.

Ozone



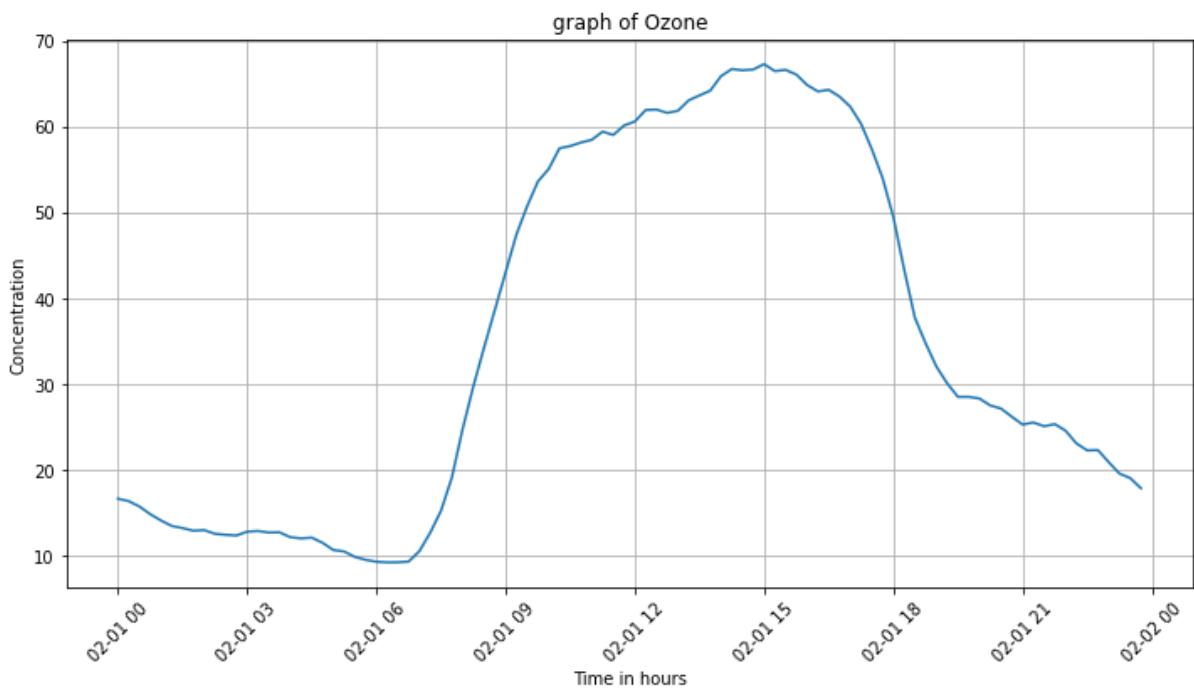
- Ozone is a highly reactive gas that can cause respiratory issues and exacerbate existing respiratory conditions. Inhalation of high levels of ozone can lead to respiratory symptoms such as coughing, throat irritation, chest tightness, and difficulty breathing
- In coal mining areas, the presence of ozone can interact with other pollutants, such as volatile organic compounds (VOCs) and nitrogen oxides (NOx), in the presence of sunlight, leading to the formation of smog.

➤ The Daily Average Concentration of NH₃ throughout 3 months from 1 Feb 2023 to 1 May 2023 is given below



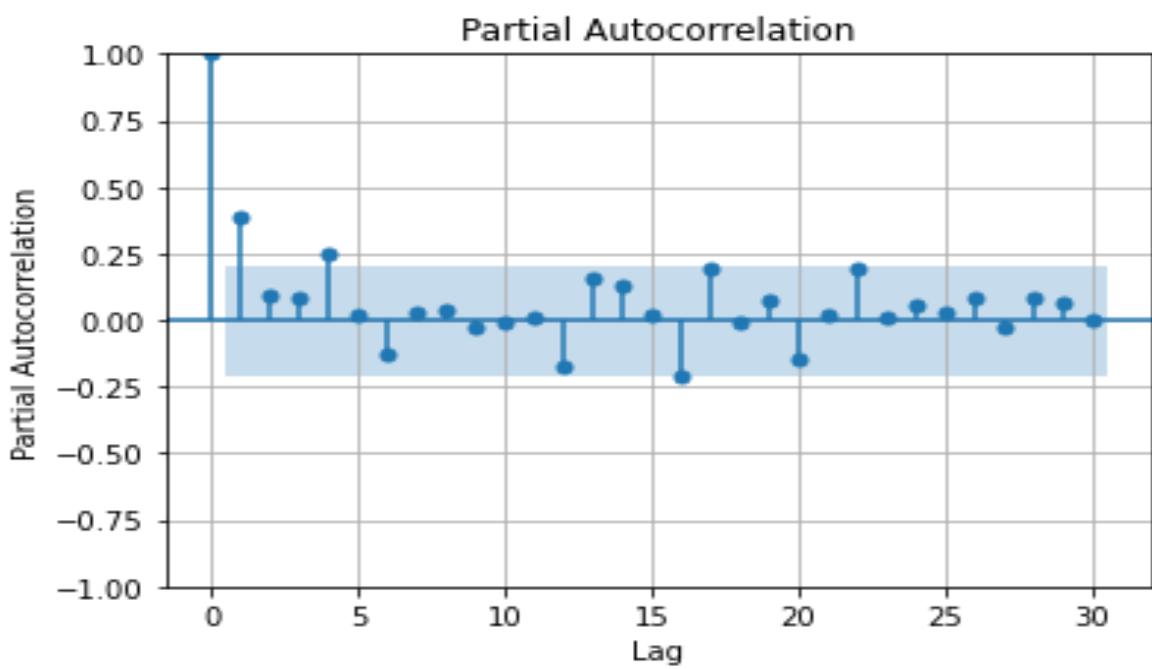
- The Daily Average Graph of Ozone reaches its peak on 21 April with $54.34 \mu\text{g}/\text{m}^3$ average concentration
- The Daily Average Graph of Ozone reaches its bottom on 5 March with $18.25 \mu\text{g}/\text{m}^3$ average concentration

➤ The Timely Average throughout 3 months

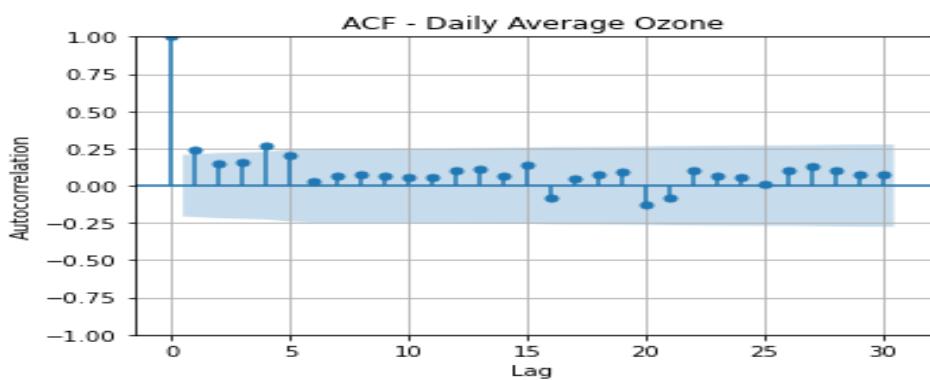


- The Maximum Concentration of Ozone is around 3:00 pm with 67.33 $\mu\text{g}/\text{m}^3$ in the daytime.
 - The Minimum Concentration of Ozone is around 6:15 am with 9.23 $\mu\text{g}/\text{m}^3$ in the daytime.
 - Ozone is inversely correlated with most of the gases in the dataset
 - Ozone is not directly formed in the coal mines; it is the by-product of chemical reaction between NOx and VOCs (Volatile Organic Compound) in the presence of sunlight .
 - VOCs + NOx = Ozone (In the presence of sunlight)
 - The Day graph of Ozone Reaches its peak when intensity of sunlight is high in daytime and it decreases with the sunlight .

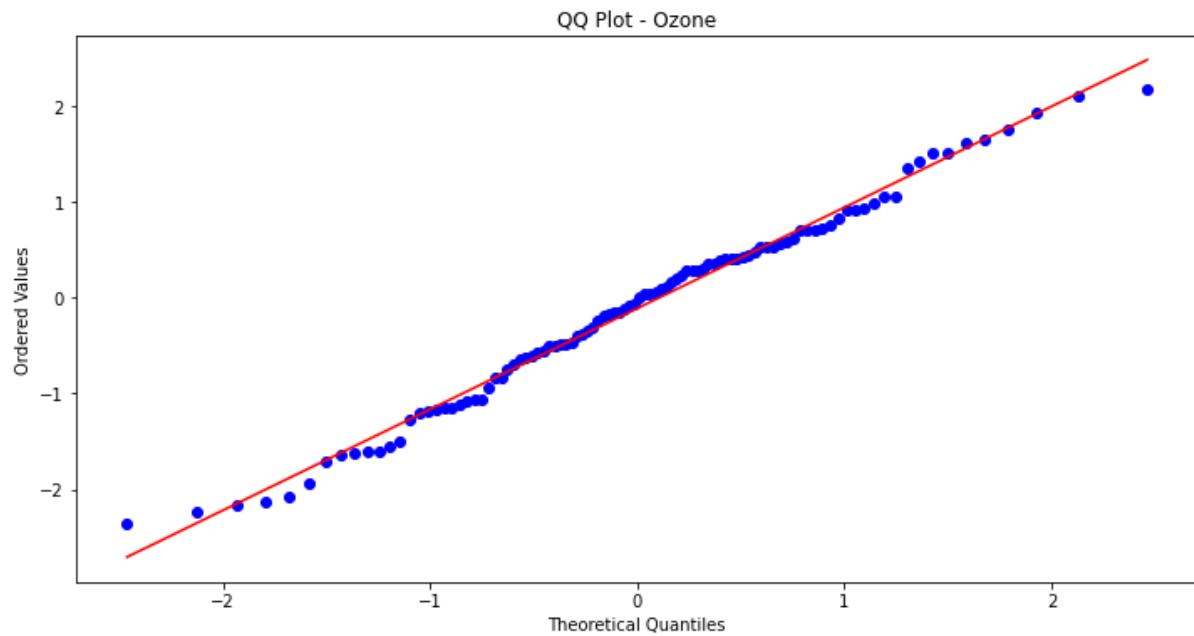
➤ Partial ACF of Ozone-



➤ ACF of Ozone -



➤ QQ-Plot of Ozone-



- The QQ plot of Ozone does not seem to be following a straight line. We can infer that Daily average of Ozone concentration is not a normal distribution.

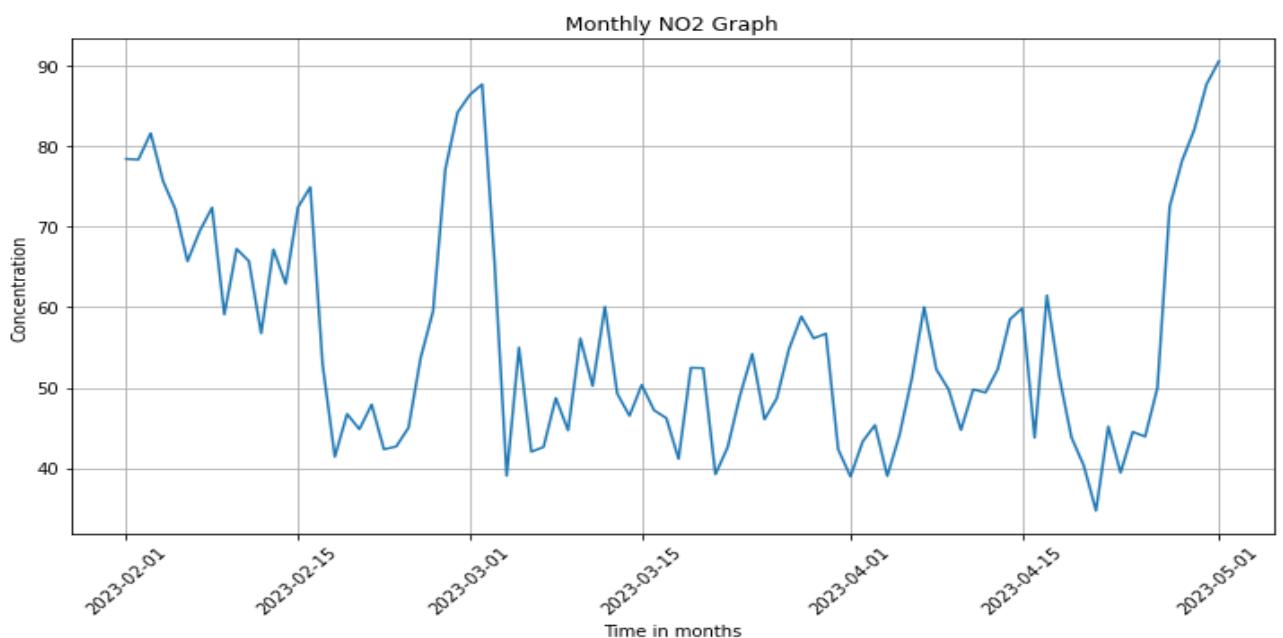
NO₂ ($\mu\text{g}/\text{m}^3$)



- NO₂ is a highly reactive gas that can irritate the respiratory system. Prolonged exposure to elevated levels of NO₂ can cause respiratory symptoms such as coughing, wheezing, shortness of breath, and chest tightness.

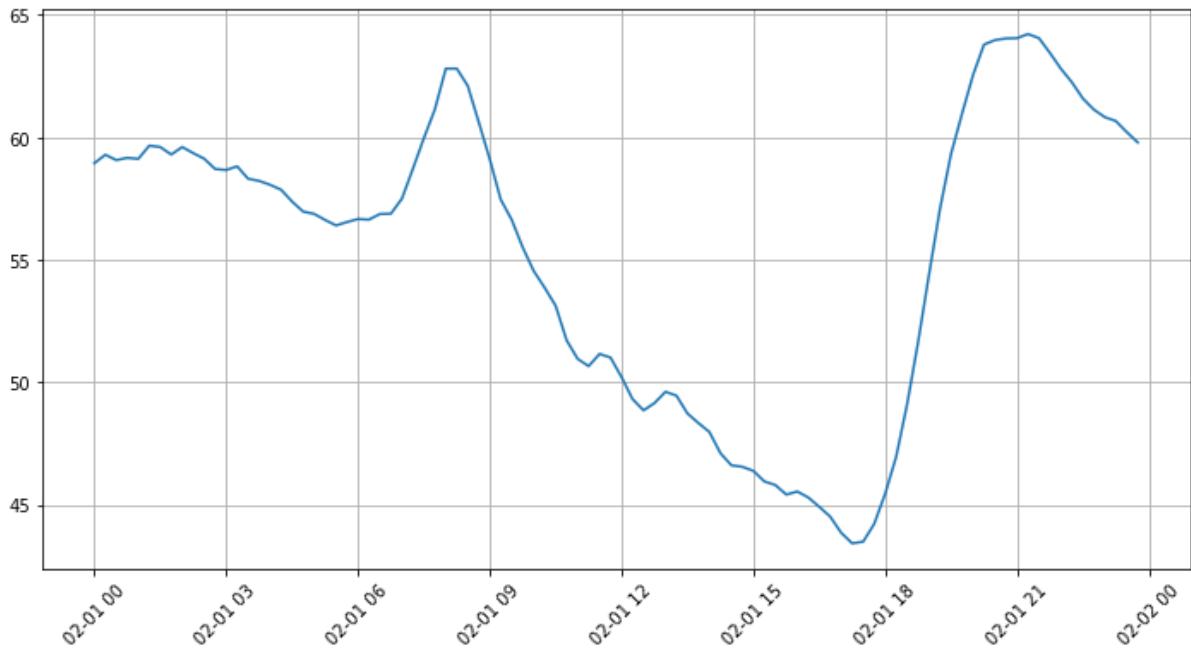
- NO₂ is a major contributor to air pollution and can have detrimental effects on the environment. In coal mining areas, NO₂ emissions can contribute to the formation of smog and ground-level ozone, leading to poor air quality

➤ The Average Concentration of NO₂ throughout 3 months from 1 Feb 2023 to 1 May 2023 is given below



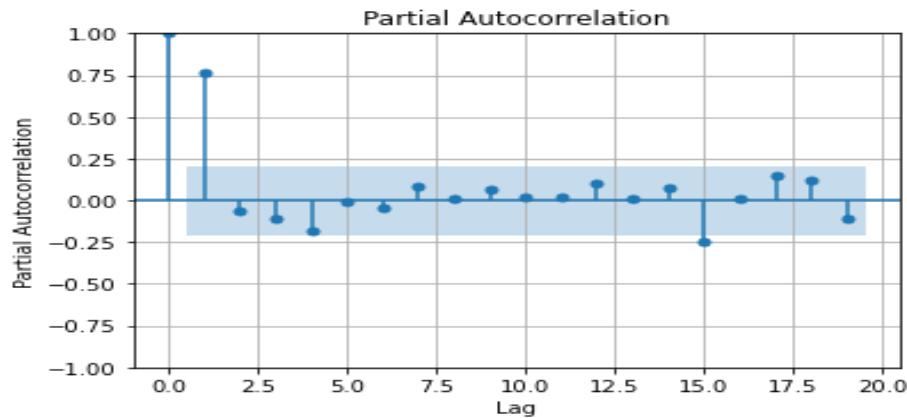
- The Daily Average Graph of NO₂ reaches its peak on 1 March with 77.5 $\mu\text{g}/\text{m}^3$ average concentration.
- The Daily Average Graph of Ozone reaches its bottom on 30 April with 7.28 $\mu\text{g}/\text{m}^3$ average concentration.

➤ The Timely Average throughout 3 months

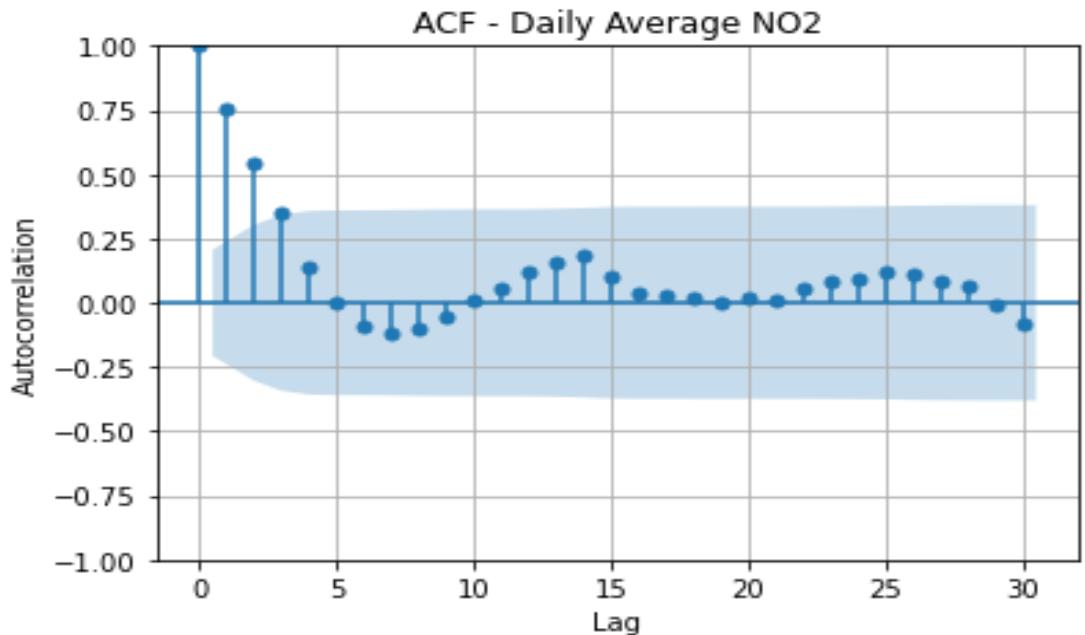


- The graph of NH₃ rises around 8:15 am with 62.84 $\mu\text{g}/\text{m}^3$ in the daytime which we expect to be the most probable time for Open pit Blasting.
- The Maximum Concentration of NO₂ is around 9:15 pm with 64.55 $\mu\text{g}/\text{m}^3$ in the daytime.
- The Minimum Concentration of NO₂ is around 5:15 pm with 43.79 $\mu\text{g}/\text{m}^3$ in the daytime.

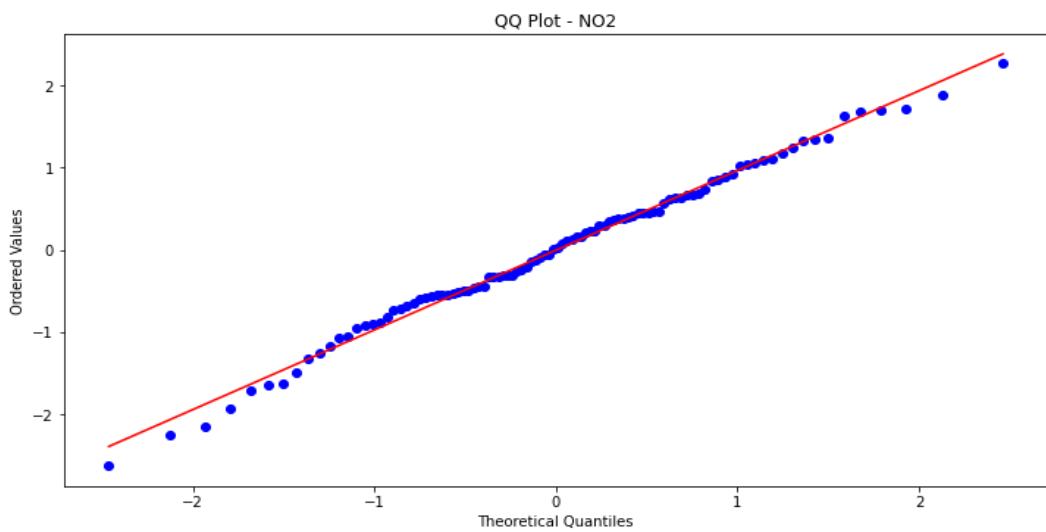
➤Partial ACF of NO₂-



➤ ACF of NO2-

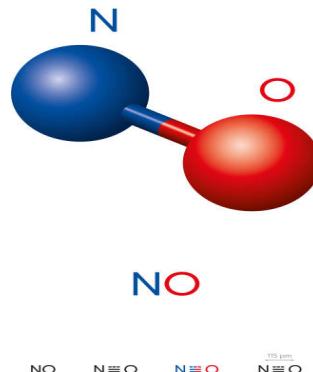


➤ QQ-Plot of NO2-

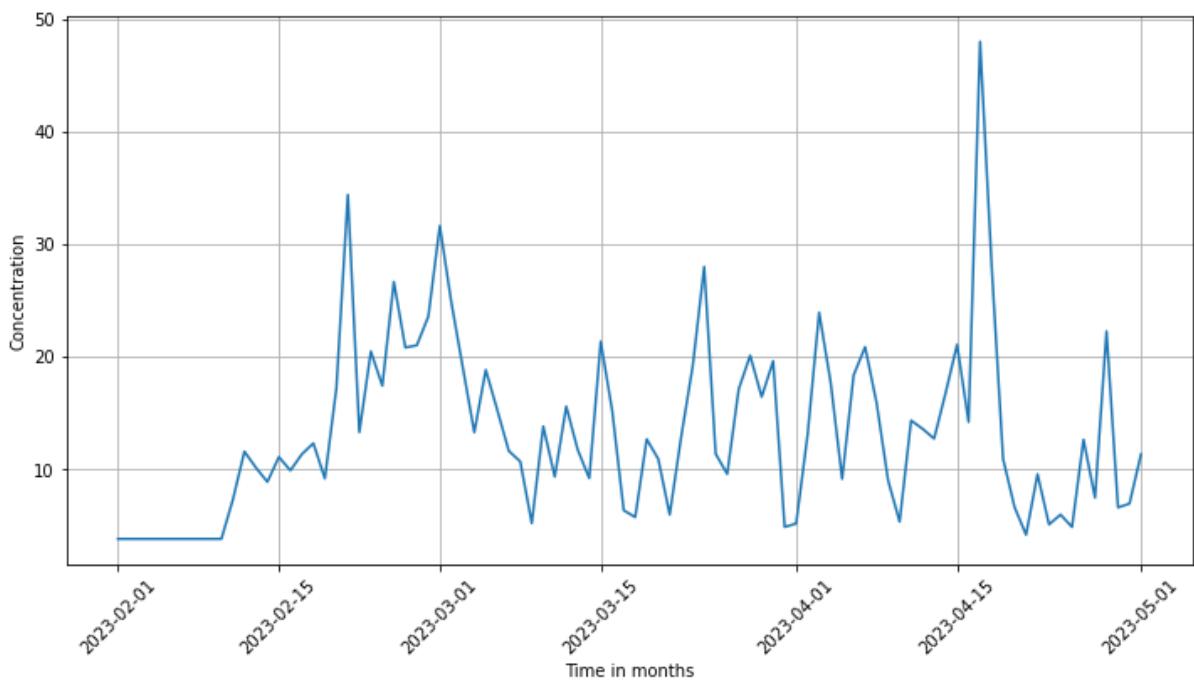


- The QQ plot of NO2 seems to be following a straight line . We can infer that Daily average of NO2 concentration is a normal distribution.

NO ($\mu\text{g}/\text{m}^3$)

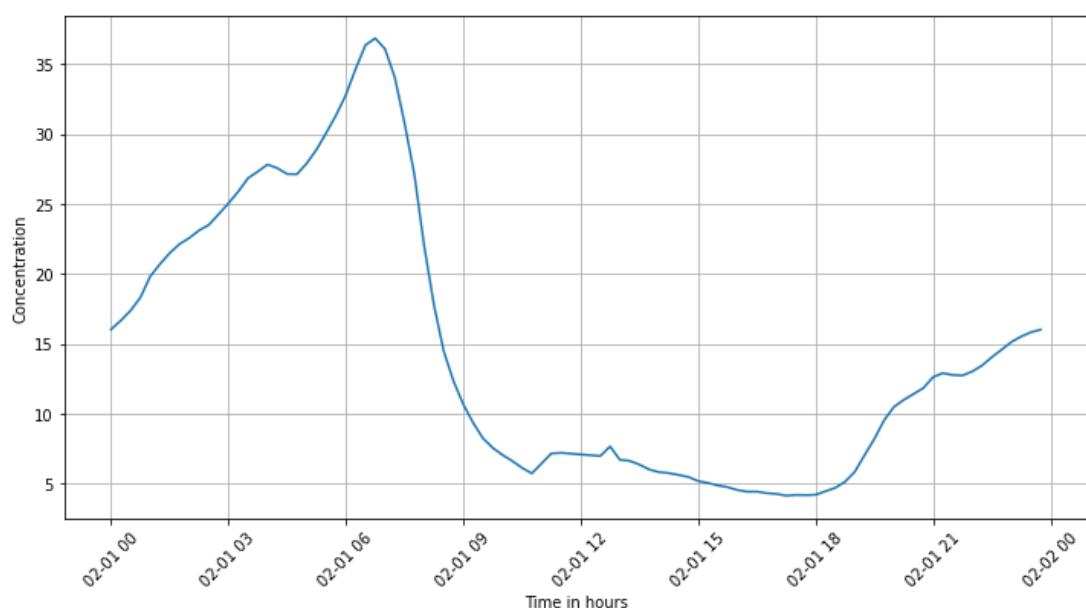


- Nitric oxide is a toxic gas that can have adverse effects on human health. Inhalation of high concentrations of NO can irritate the respiratory system, leading to symptoms such as coughing, shortness of breath, and chest pain
 - NO is a major contributor to air pollution. When released into the atmosphere from coal mining activities, NO can react with other pollutants and sunlight to form smog and ground-level ozone.
 - Nitric oxide is considered a greenhouse gas. It has the ability to absorb and emit infrared radiation, contributing to the greenhouse effect and global warming
- The Daily Average Concentration of NO throughout 3 months from 1 Feb 2023 to 1 May 2023 is given below



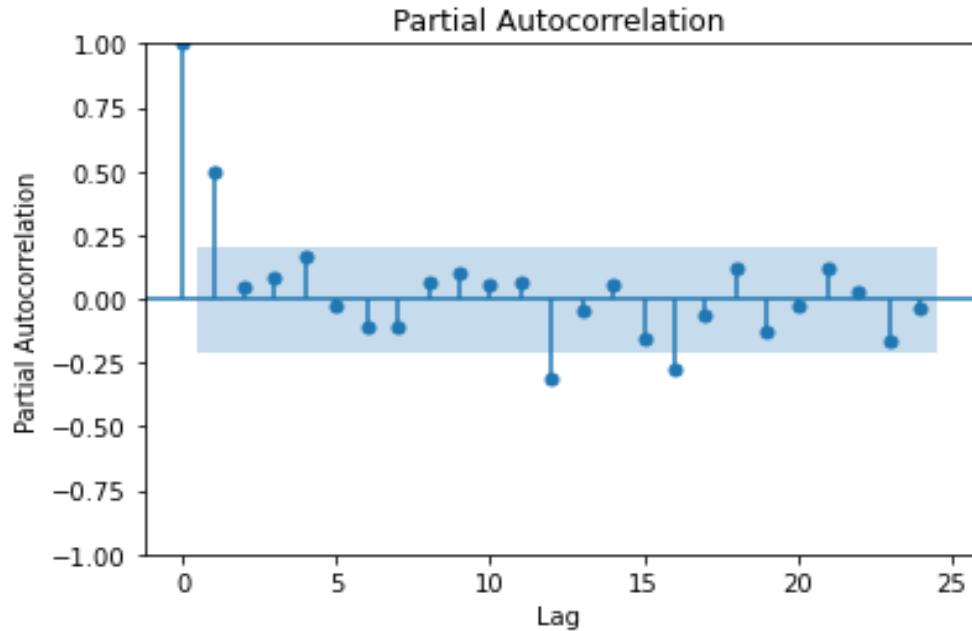
- The Daily Average Graph of NO reaches its peak on 1 February with $3.4 \mu\text{g}/\text{m}^3$ average concentration
- The Daily Average Graph of NO reaches its peak on 17 April with $47.99 \mu\text{g}/\text{m}^3$ average concentration

➤ The Hourly Average throughout 3 months

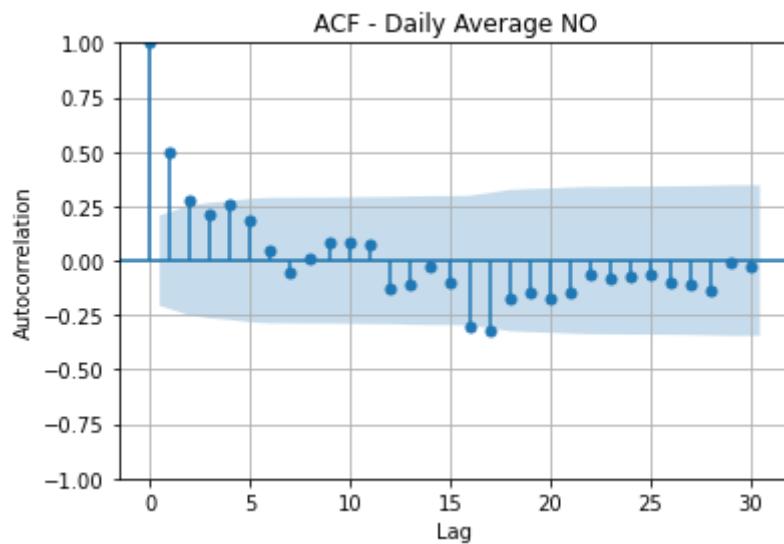


- The Maximum Concentration of NO is around 7:00 am with 36.86 $\mu\text{g}/\text{m}^3$ in the daytime
- The Minimum Concentration of NO is around 5:15 am with 4.15 $\mu\text{g}/\text{m}^3$ in the daytime

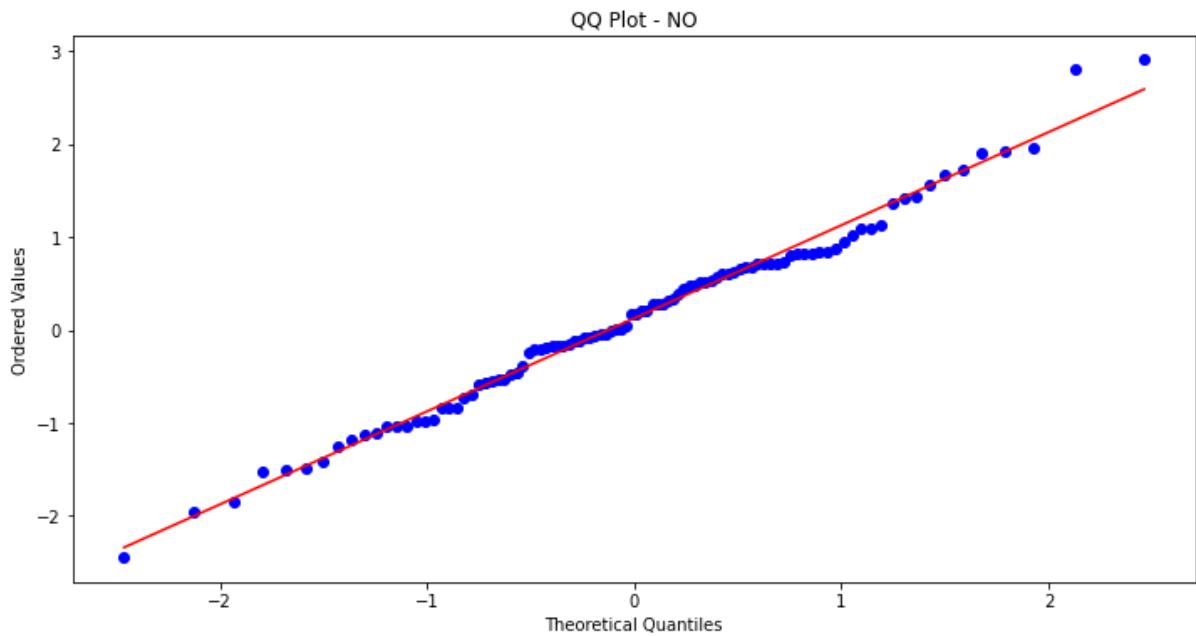
➤ Graph of PACF -



➤ Graph of ACF NO-



- QQ-Plot of NO-



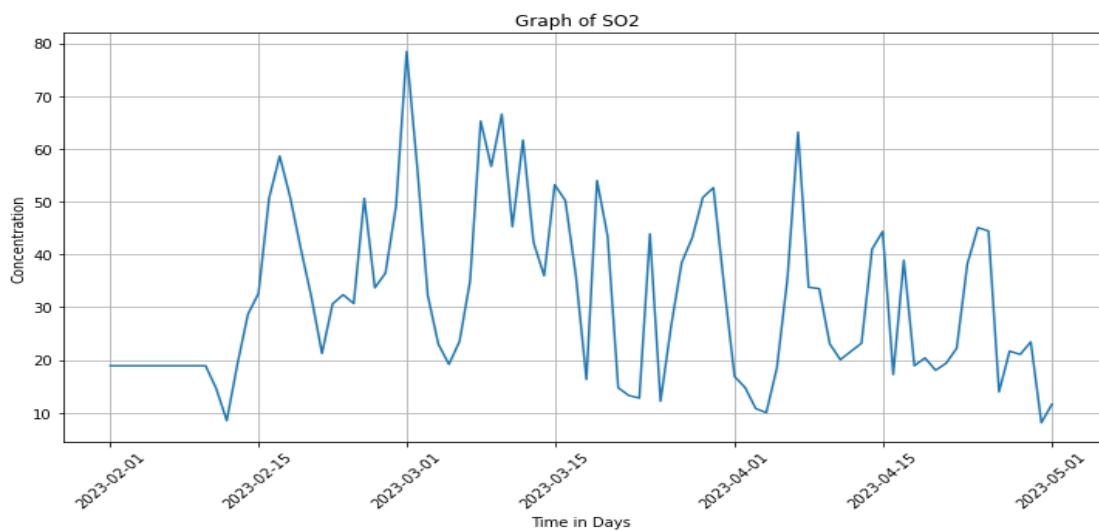
- The QQ plot of NO does not seem to be following a straight line . We can infer that the Daily average of NO concentration is not a normal distribution.

SO₂



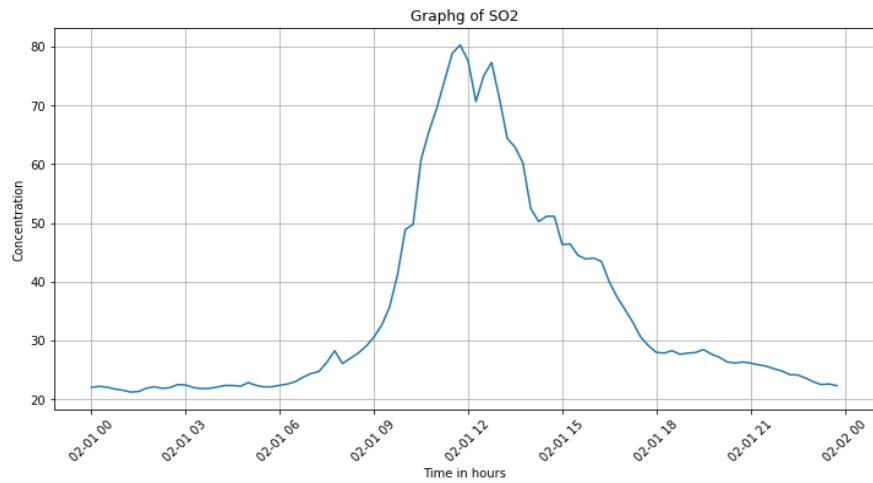
- SO₂ is a major contributor to air pollution in coal mining areas. It is released during the burning of coal or from coal processing operations. High levels of SO₂ can lead to respiratory problems, such as asthma and bronchitis, and can exacerbate existing respiratory conditions in both miners and nearby communities
- Prolonged exposure to high levels of SO₂ can have severe health effects on miners and nearby communities. It can cause irritation of the respiratory system, leading to coughing, wheezing, and shortness of breath

➤ The Daily Average Concentration of NH₃ throughout 3 months from 1 Feb 2023 to 1 May 2023 is given below



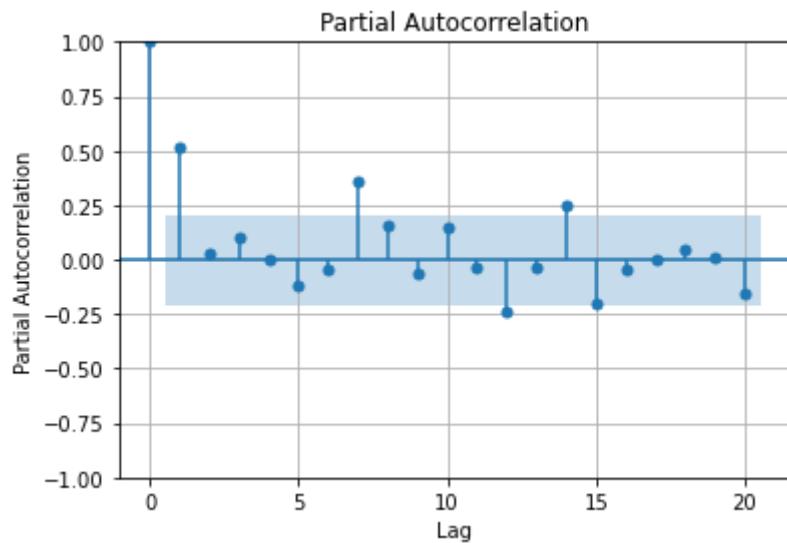
- The Daily Average Graph of SO₂ reaches its peak on 1 March with $77.50 \mu\text{g}/\text{m}^3$ average concentration
- The Daily Average Graph of SO₂ reaches its bottom on 30 April with $7.28 \mu\text{g}/\text{m}^3$ average concentration

➤ The Hourly Average throughout 3 months

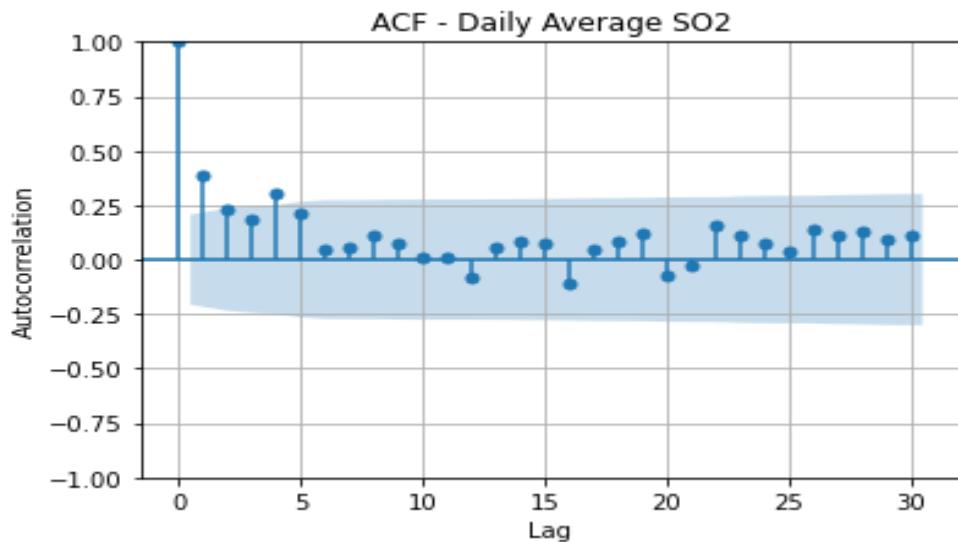


- The Maximum Concentration of SO₂ is around 11:45 am with 80.24 $\mu\text{g}/\text{m}^3$ in the daytime
- The Minimum Concentration of SO₂ is around 1:15 am with 21.22 $\mu\text{g}/\text{m}^3$ in the late night.

➤Partial ACF of SO₂-

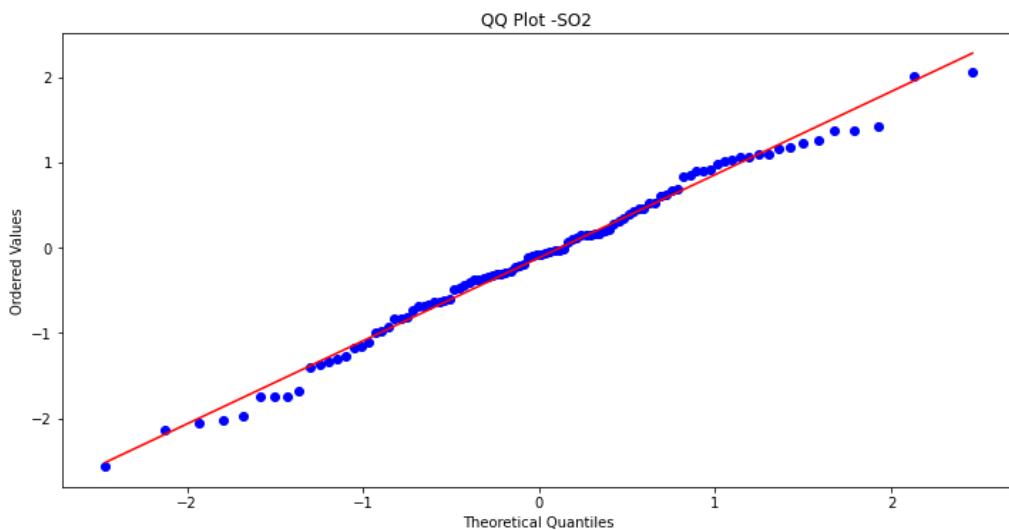


➤ACF of SO₂-



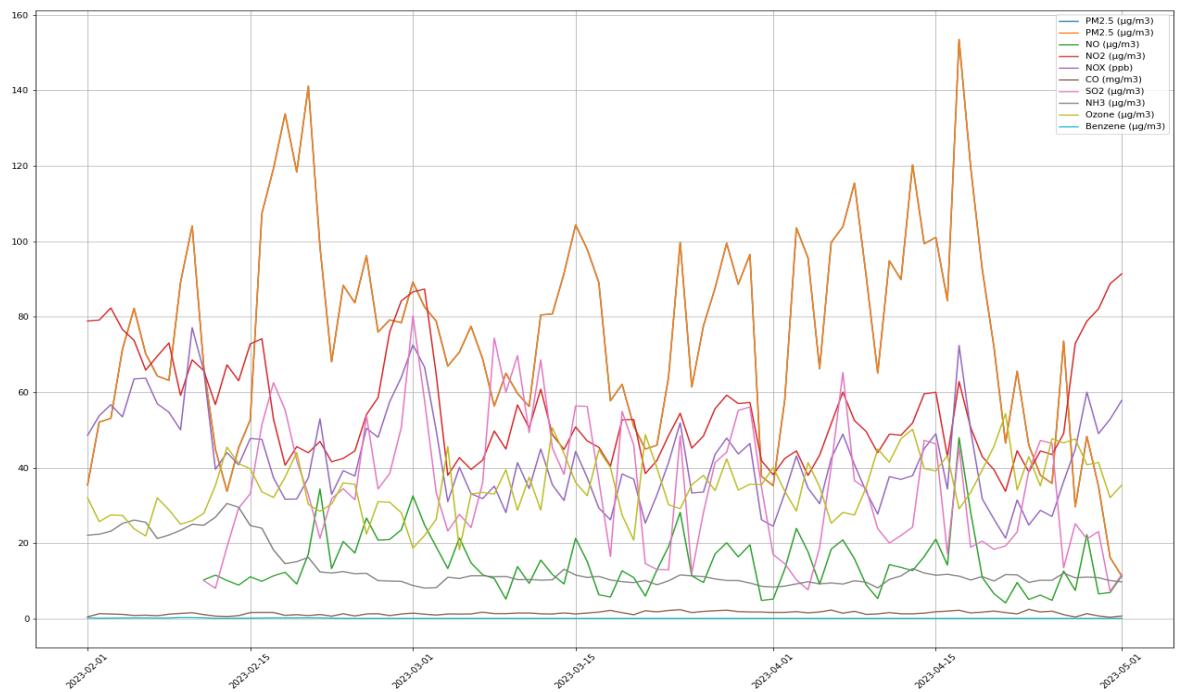
- ACF is not falling instantly and has 3 significant peaks ,ARMA model will be used

➤QQ-Plot of SO2-



- The QQ plot of SO2 seems to be following a straight line . We can infer that the Daily average of SO2 concentration is a normal distribution.

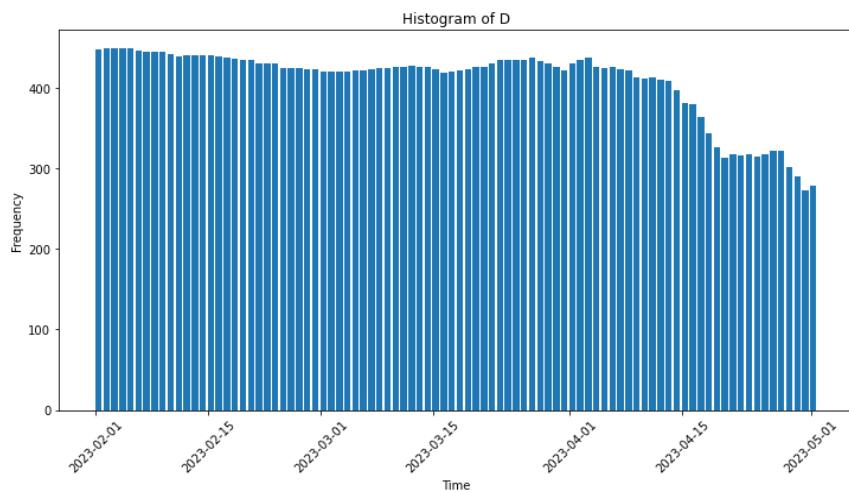
Important Inferences



- The Data that we have given is not trending with very less or no seasonality.
- The Daily Average Graph of most of the pollutants goes down around 21 April which may give us an idea about rain in that region .
- When we Observe the Average hourly data of most gases we observe the minimum around evening this may be due to reduced mining activities in evening .

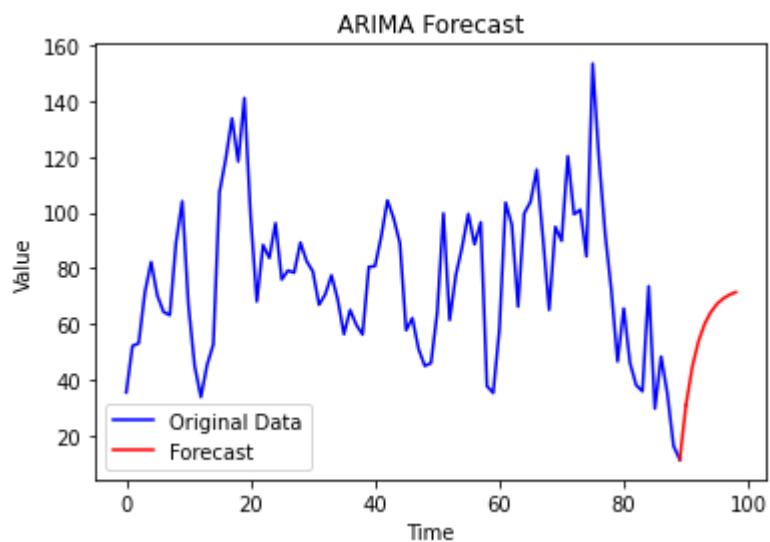
- The most Probable time for the open pit blasting is around 7:15 am to 8:15 am . We reached such a conclusion after observing a spike in hourly average graphs of most gases which are released in open pit blasting .
- Ozone formation takes place in the presence of sunlight , as the intensity of sunlight increases the formation of Ozone increases and it started declining with the decrease in intensity of sunlight .
- Ozone is in negative correlation with NOx, NO2 and VOCs like Benzene .

➤ Histogram of the Open pit blasting time throughout 3 months

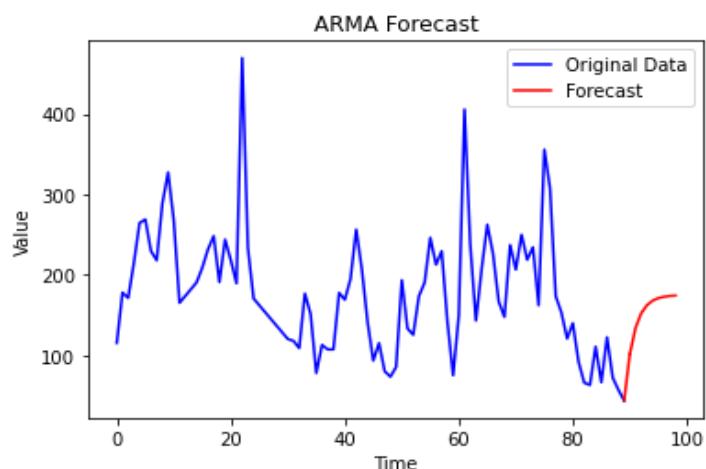


Forecasting

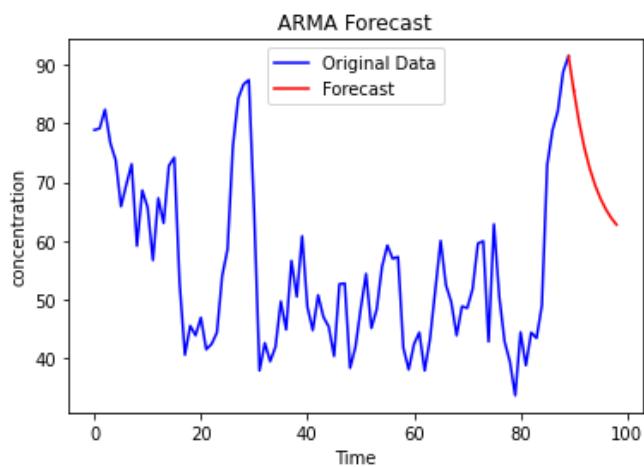
PM2.5-



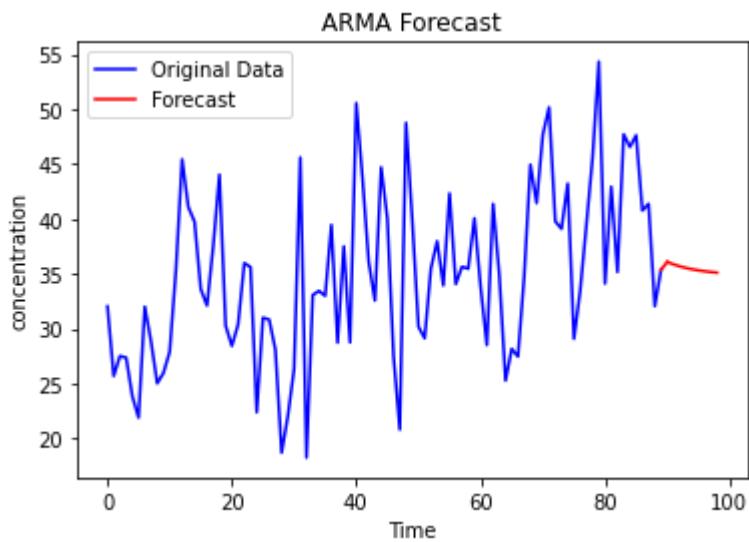
PM10-



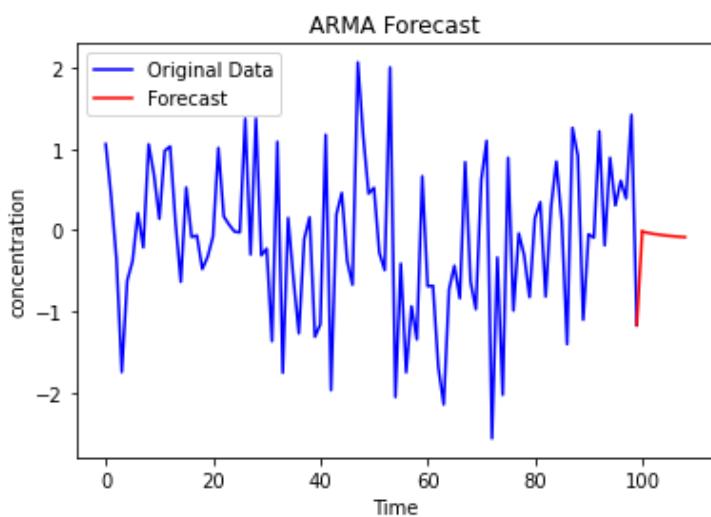
NO2-



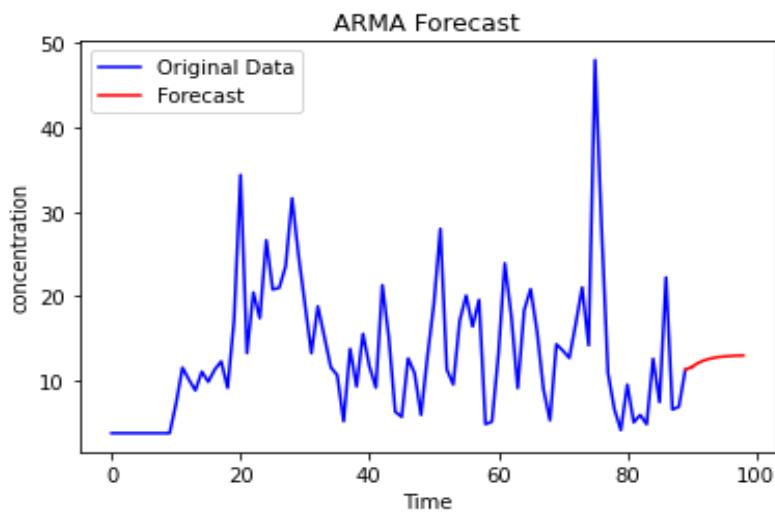
Ozone-



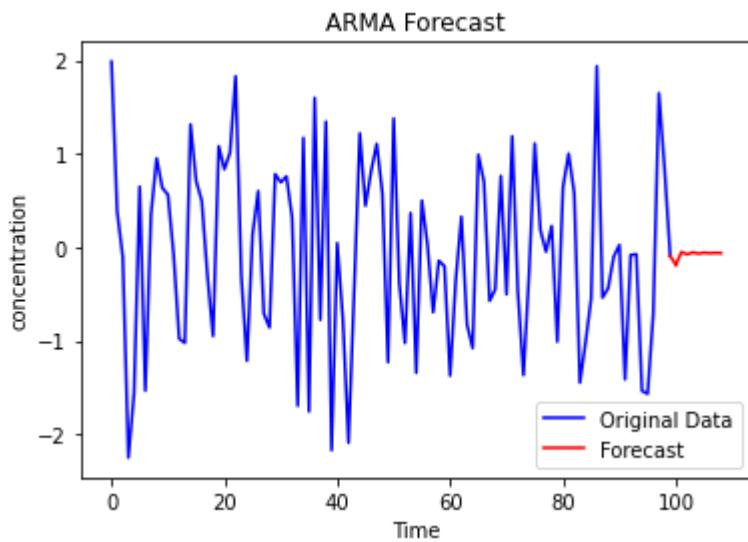
SO2-



NO-



NH3-



Interpolation-

- Used linear interpolation to fill up the missing values in the dataset
- Tried using quadratic and cubic interpolation but some graphs are coming negative .