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The Influence of Ozone Depletion Potential Weighted Anthropogenic Emissions of Nitrous Oxide

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Abstract: The effects of anthropogenic emissions of nitrous oxide (N_2O), carbon dioxide (CO_2), methane (CH_4), and halocarbons on stratospheric ozone (O_3) over the twentieth and twenty-first centuries are divided using a chemical model of the stratosphere. As halocarbon levels revert to pre-industrial levels, N_2O and CO_2 will likely play the primary roles in the evolution of ozone in the future. It is unable to distinguish clearly between these gases' effects on ozone due to nonlinear interactions between them. The work was conducted using the monthly and annual data of the gases in the stratospheric layer to determine the overlap between N_2O and O_3 for the Iraq station and for the period (2003-2016). The strength of the association between gases was determined using the Spearman rho test (rs). It was found that there is a very high positive relationship between the N_2O and O_3 in Nasriyah station, which is 0.807 which indicates a strong association. This is because meteorological conditions, climatic fluctuations, and atmospheric location all affect correlation. The ozone layer is destroyed by nitrous oxide at high concentrations through the stratosphere layer and the tropospheric layer, the concentration of ozone increases with an increase in the concentration of nitrogen dioxide.

Key words: Greenhouse gases, N_2O, O_3, ECMWF, Spearman rho test, Iraq.

Introduction

Many different substances, most notably the chlorofluorocarbons (CFCs) that are to blame for the Antarctic ozone hole, degrade the ozone layer in the stratosphere. In addition to having anthropogenic and natural origins, nitrous oxide also depletes the ozone layer. Additionally, unlike CFCs, their usage and emission are not governed by the Montreal Protocol, which has assisted in slowing the ozone hole's pace of expansion (Abbood & Al-Taai, 2018).

The Nitrous oxide gas is one of several nitrogen oxides, nitrous oxide (N_2O), nitrous, also referred to as laughing gas, dinitrogen monoxide, or nitrous oxide, is a colourless gas with a pleasant, sweetish odour (Zhou et al., 2020). For brief surgical procedures, nitrous gas is typically employed as an anesthetic, prolonged inhalation results in death and the majority of N_2O is released into the atmosphere from both natural and human sources (Wang, 2007). With soil beneath natural vegetation accounting for 60% of all naturally produced emissions, nitrous oxide is a significant source of pollution. Oceans make up 35% of other natural resources, and air chemical reactions account for 5%. Fertilised soil and compost make up 42% of anthropogenic emissions, whereas runoff and fertiliser washing make up 25%, biomass burning accounts for 10%, fossil fuel combustion, and industrial processes account for 10%, nitrogen accounts for 9%, and human sewage accounts for 5%. Through soil cultivation, the

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application of nitrogen fertilisers, and the management of animal waste, agriculture encourages the formation of nitrous oxide. These actions encourage naturally occurring microorganisms (Wahiduzzaman & Yeasmin, 2007). As a greenhouse gas, N_2O has a substantial effect on global warming. Nitrous oxide contributes less to the greenhouse effect than carbon dioxide due to its low concentration (less than 1/1000 of CO_2 concentration), as well as less than that of H_2O and CH_4. Nitrous oxide has 298 times the atmospheric capacity to capture carbon dioxide over a period of 100 years. As a result of human activity, which is responsible for 38% of the atmospheric N_2O and whose concentration has increased by 15% since 1750, attempts to limit greenhouse gas emissions also include controlling N_2O (Revil, 2008). The ozone layer thins as a result of nitrous oxide. A recent study indicates that N_2O emissions are currently anticipated to be the most significant (ODS) emissions. Since 1750, the amount of tropospheric ozone on the planet is thought to have increased by 30%. Surface emissions are predicted to continue to rise steadily as the O_3 response continues to rise (Noh, 2003). The northern hemisphere has higher ozone concentrations than the southern hemisphere, with monthly ozone concentrations in the northern hemisphere ranging from 35 to 50 ppm. O_3 concentrations are at their highest during summertime in North America and Europe, with daily peaks in the late afternoon. O_3 concentrations can reach (200-400) ppb in metropolitan areas, which are extremely high concentrations that happen by accident. Climate is a critical factor in driving the generation and depletion of ozone, a significant greenhouse gas (Nassif et al., 2021). Ozone is now a problem beyond only air quality. The benefits of controlling air quality are maximised, and negative effects on people's health, the environment, and the climate system are diminished, with closer cooperation between the international climate and O_3 (Nassif et al., 2020). It would be possible to meet the goals for combating climate change, O_3, and other air quality issues by preventing deforestation, controlling biomass burning, and reducing methane emissions.

The best integration between energy and climate change is provided by biofuels, and the O_3 rules will help to avoid unexpected consequences (Lothon et al., 2009). Numerous studies have been carried out to demonstrate the impact of N_2O gas on the ozone layer. The monthly average of O_3, INSR, and Temp over the Baghdad station showed that O_3 was highest in spring and lowest in summer, while INSR and T were highest in summer and lowest in winter. Additionally, the overall (1979–2012) Trend Analysis showed negative trends for all of the months in the five stations that were taken into consideration, except the Baghdad station's July and August results, which showed a strong positive trend that referred to a significant improvement in TOC that reached (0.443) DU/Year (Yehia et al., 2022). This study also shows TOC unfavourable trends that are thought to be caused by the burning of biomass and anthropogenic trace gases in Baghdad City. Since CO_2 and CH_4 are the sources of photochemical ozone generation, it is hypothesised that TOC will continue to decline unless anthropogenic emissions of ozone precursors are maintained at constant levels or even decreased (Al-Taai et al., 202; Yehia et al., 2022).

Methodology

Data Source and Study Stations

In this study, the average of the data for nitrous oxide and ozone for each month for the period (2003-2016) for the Iraq regions and neighbours was acquired from the European Center (ECMWF). Ozone and nitrous oxide gas monthly and annual behaviour should be calculated, and the strength of the association between the two should be evaluated using Spearman's test (Al-Taai & Abbood, 2020; Al-Taai & Abbood, 2020). The reason for choosing the region is that it has a clear influence among the chosen regions in northern, southern, and central Iraq (as shown in Table 1).

Table 1: Latitude, longitude and elevation for study stations in Iraq (Al-Taai et al., 2021)

Station	*Latitude °N*	*Longitude °E*	*Elevation in meters*
Mosul	36°34′00″	43°13′00″	223
Sulaymaniyah	35°33′26″	45°26′08″	882
Haditha	34°08′23″	42°22′41″	107
Baghdad	33°18′55″	44°21′58″	34
Amarah	32°00′00″	47°00′00″	12
Nasiriyah	31°02′38″	46°15′27″	9
Basrah	30°30′54″	47°48′36″	5

Statistical Analyses

The Spearman's Rank correlation coefficient can be used, to sum up the strength and direction (positive or negative) of a link between two variables (AL-Salihi, 2011). Pearson's correlation examines linear relationships, whereas Spearman's correlation assesses monotonic relationships (whether or not they are linear) (Ahmed et al., 2021). A perfect Spearman correlation of

+1 or 1 occurs when one variable is a perfect monotone function of the other when there are no repeated data values. If both variables are measured using an ordinal scale, the Spearman test is not necessary if the data distribution is linear, both variables are assumed to be ranked RX and RY, respectively, and D is assumed to represent the difference between the two rankings. This equation's Spearman rank correlation coefficient (rs) is as follows (Abbood& Al-Taai, 2020):

$$rs = 1 - \frac{6\sum_{i=1}^{n} di^2}{(n^2 - 1)} \quad (1)$$

where rs is Spearman correlation coefficient, n: sample size, D: The distinction between two pairs of ranks.

Results and Discussion

Analysis of Ozone Concentration Behaviour in Iraq

Figures 1-7 show that the ozone concentrations are high during the winter and spring and begin to decrease during the summer and fall, especially for the years 2010-2011-2012. In all the stations, this is due to astronomical and tropical factors and their changes during the seasons and years, as well as the nature of the region and the natural and human activities that increase the concentration of ozone in the troposphere. Where the winter season represents very high concentrations, and less concentration during the autumn season in Mosul,

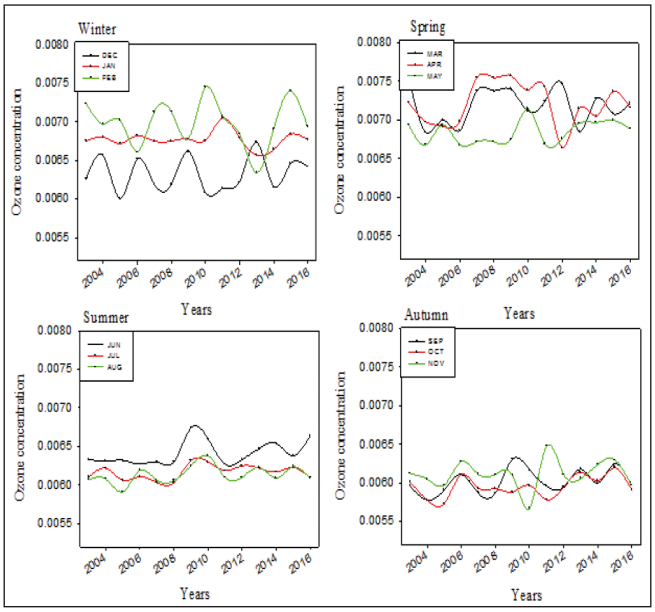


Figure 1: The behaviour of ozone concentrations for a yearly average (three months in the season) in Mosul station for the period (2003-2016).

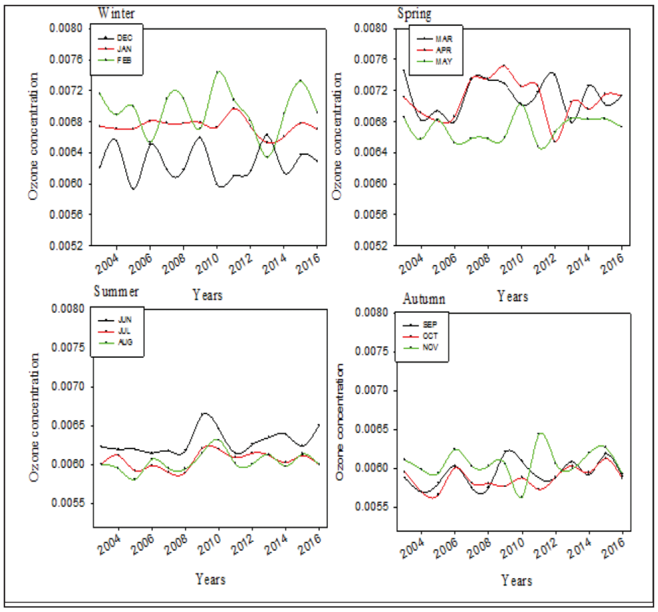


Figure 2: The behaviour of ozone concentrations for a yearly average (three months in the season) in Sulamaniyah station for the period (2003-2016).

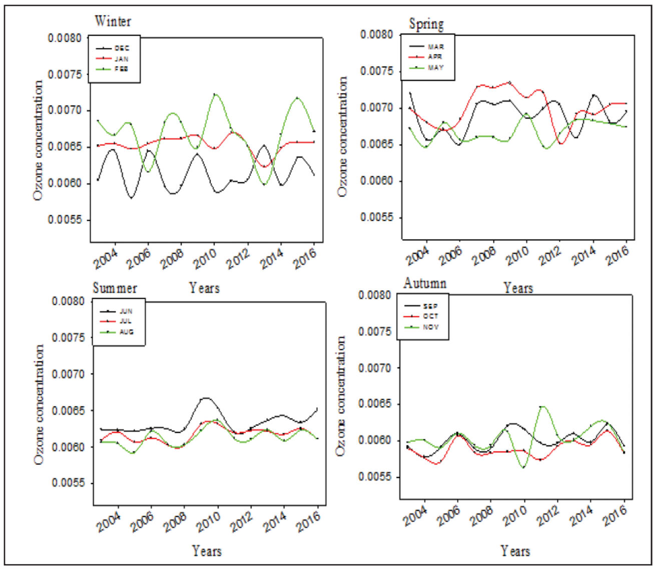


Figure 3: The behaviour of ozone concentrations for a yearly average (three months in the season) in Haditha station for the period (2003-2016).

Sulaymaniyah, Haditha, Amarah, Baghdad, Nasiriyah, and Basra stations, it may reach a value of 0.0072.

Analysis of Nitrous Oxide Concentration Behaviour in Iraq

Figures 8-14 show that N_2O concentrations are high during the spring and summer, and begin to decrease during the autumn and winter, especially for the year

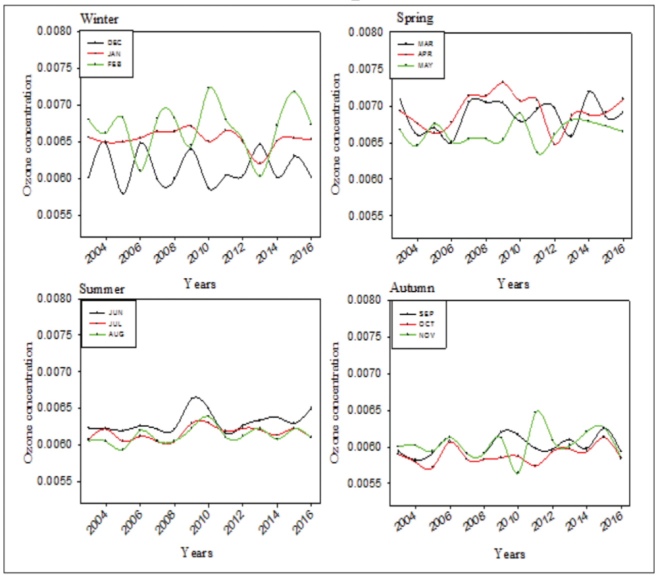


Figure 4: The behaviour of ozone concentrations for a yearly average (three months in the season) in Baghdad station for the period (2003-2016).

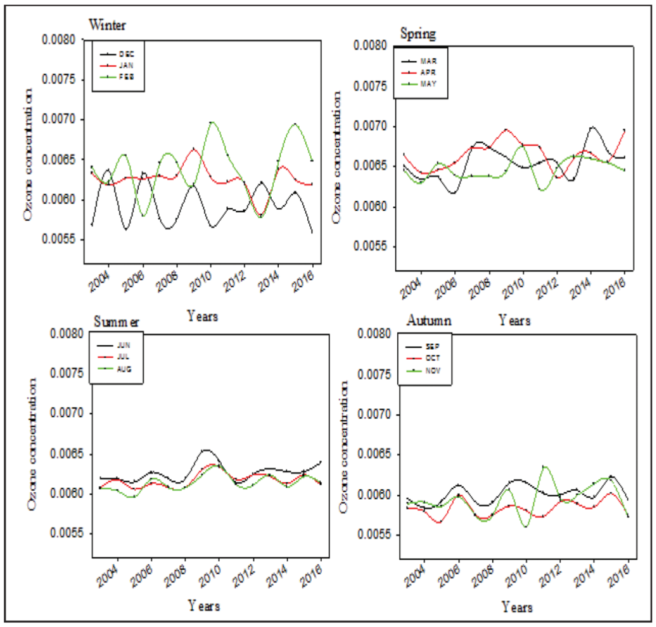


Figure 5: The behavior of ozone concentrations for a yearly average (three months in the season) in Amarah station for the period (2003-2016).

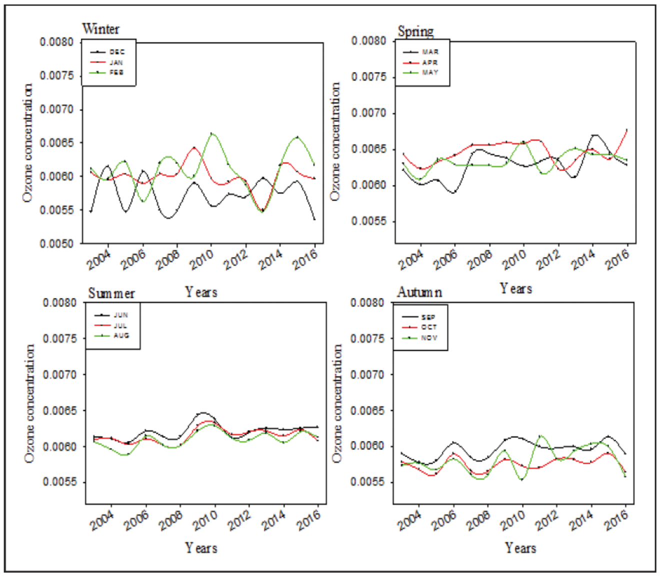


Figure 6: The behaviour of ozone concentrations for a yearly average (three months in the season) in Nasiriyah station for the period (2003-2016).

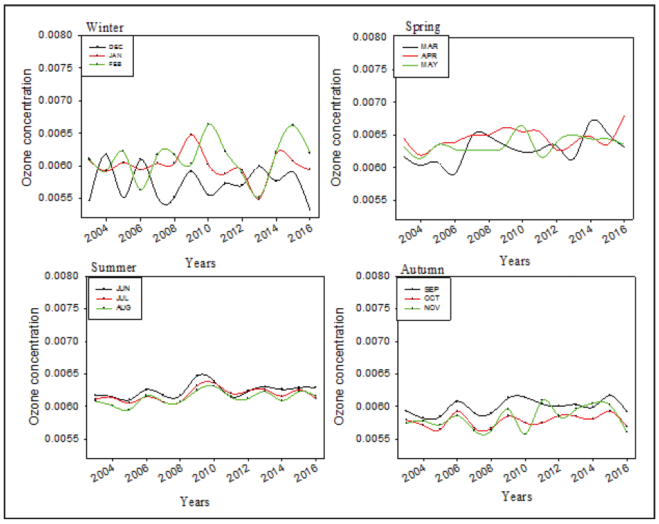


Figure 7: The behaviour of ozone concentrations for a yearly average (three months in the season) in Basrah station for the period (2003-2016).

2003. These chemicals are created in all of the Iraqi stations not by the direct combustion of fuel but rather by high-temperature chemical interactions between nitrogen and oxygen in the air brought on by the burning of fuel in power plants and motors. The primary sources of pollution that cause high amounts of nitrogen to be released in the engines of cars in relation to engine size and vehicle speed are transportation and power plants. Because high speed increases the amount of nitrogen entering the engine, the amount of nitrogen oxides produced by the vehicle increases with speed. Additionally, the ozone layer is being destroyed as a result of high amounts of nitrous oxide caused by the burning of industries, laboratories, cars and war remains.

Relationship Between the Ozone and Nitrous Oxide Concentrations

Figure 15 and Table 2 show the type of relationship and the strength of the correlation between ozone and nitrous oxide concentrations in Iraq city at the yearly mean for

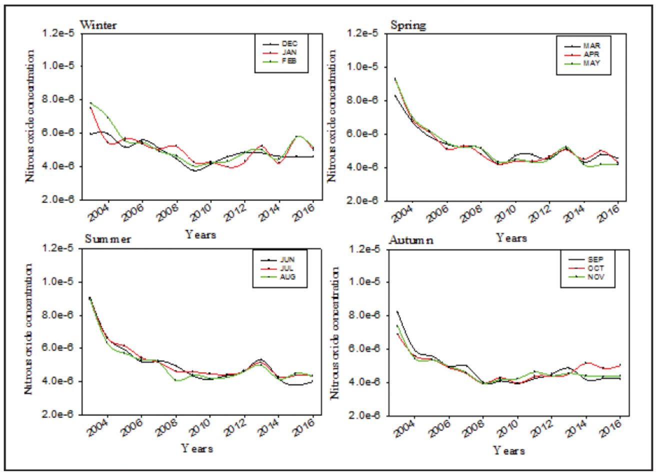


Figure 8: The behaviour of nitrous oxide concentrations for a yearly average (three months in the season) in Mosul station for the period (2003-2016).

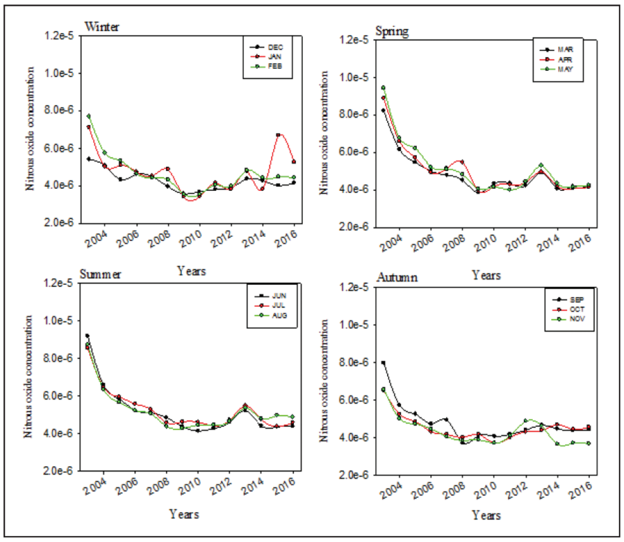


Figure 9: The behaviour of nitrous oxide concentrations for a yearly average (three months in the season) in Sulamaniyah station for the period (2003-2016).

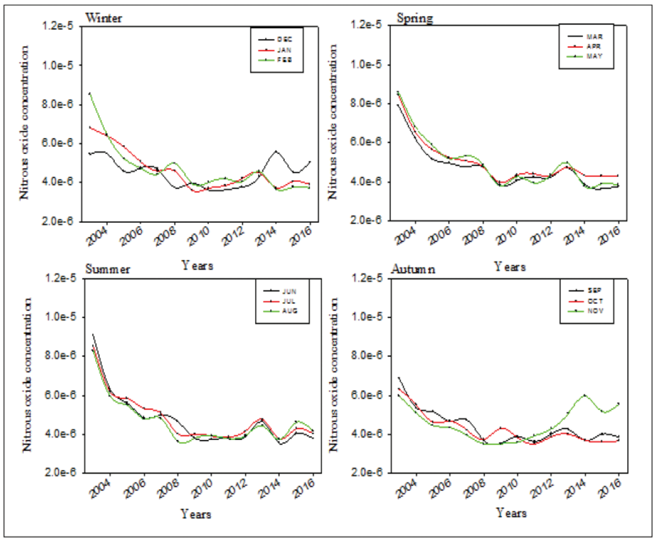


Figure 10: The behaviour of nitrous oxide concentrations for a yearly average (three months in the season) in Haditha station for the period (2003-2016).

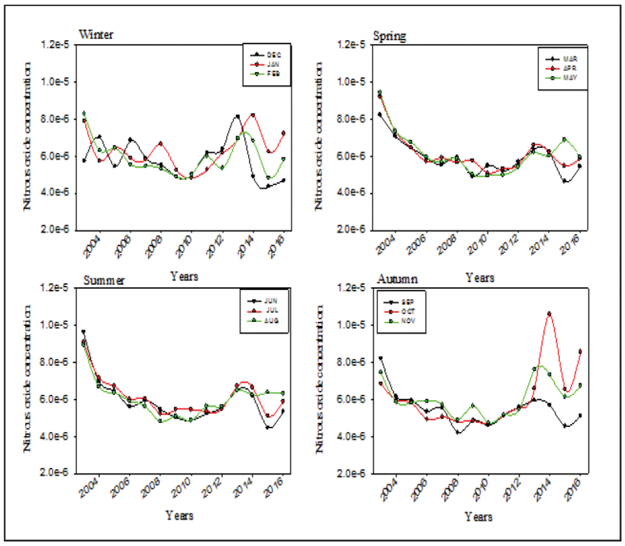


Figure 11: The behaviour of nitrous oxide concentrations for a yearly average (three months in the season) in Baghdad station for the period (2003-2016).

Table 2: Strength and correlation coefficient between ozone and nitrous oxide concentrations for Iraq station

Stations	*Spearman rho*		*Simple linear regression*	
	rs	*Correlation*	*P-value*	*Relationship*
Mosul	0.740	High	0.001	Linear
Sulaymaniyah	0.154	V. low	0.020	Non-Linear
Haditha	0.749	High	0.041	Non-Linear
Baghdad	0.488	Middle	0.003	Linear
Amarah	0.593	Middle	0.509	Non-Linear
Nasiriyah	0.807	High	0.118	Non-Linear
Basrah	0.734	High	0.027	Non-Linear

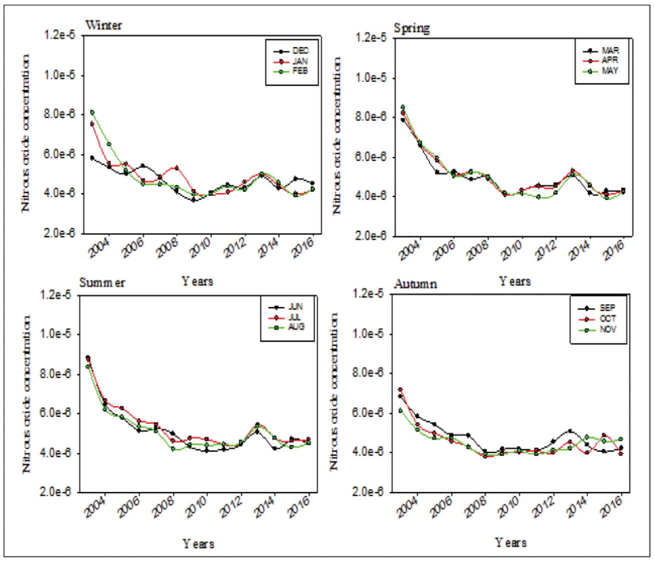


Figure 12: The behavior of nitrous oxide concentrations for a yearly average (three months in the season) in Amarah station for the period (2003-2016).

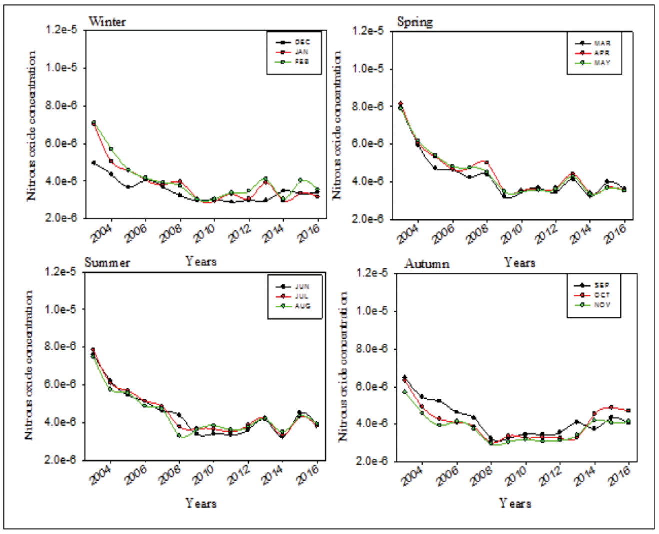


Figure 13: The behaviour of nitrous oxide concentrations for a yearly average (three months in the season) in Nasiriyah station for the period (2003-2016).

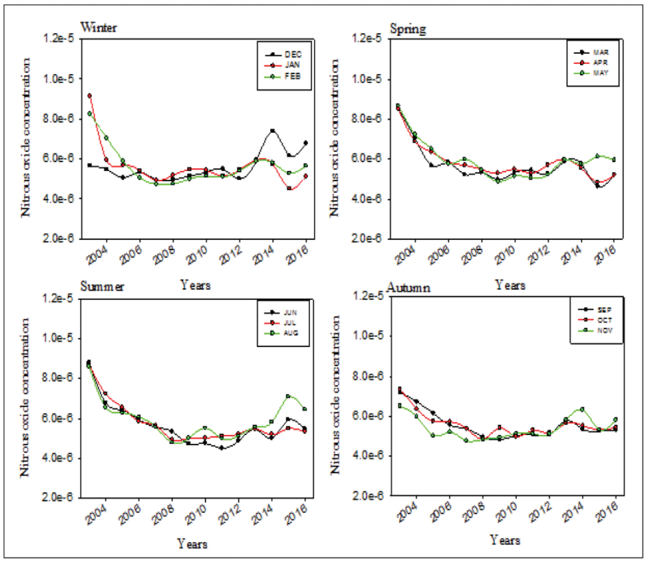


Figure 14: The behaviour ofnitrous oxide concentrations for a yearly average (three months in the season) in Basrah station for the period (2003-2016).

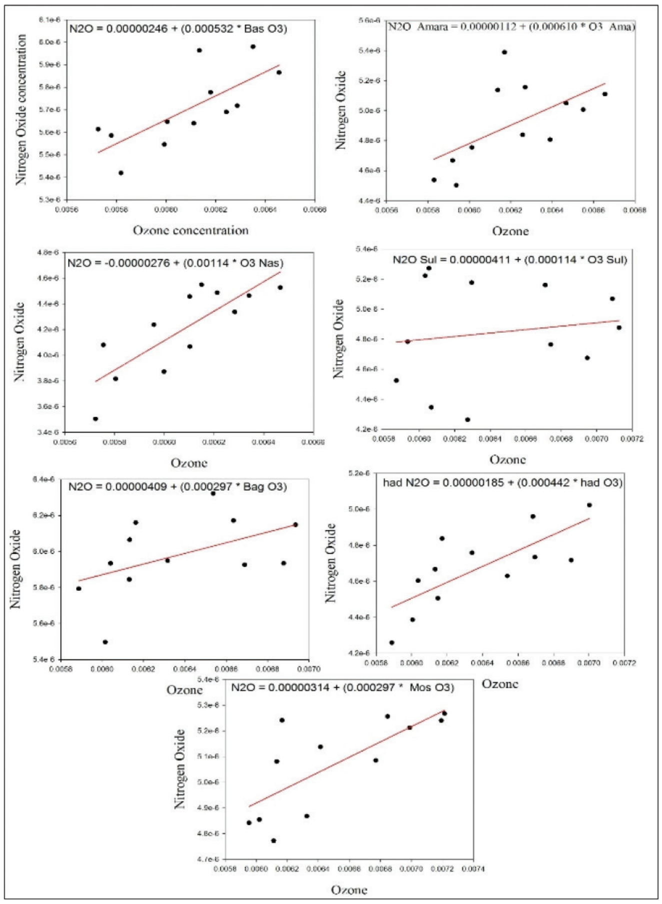
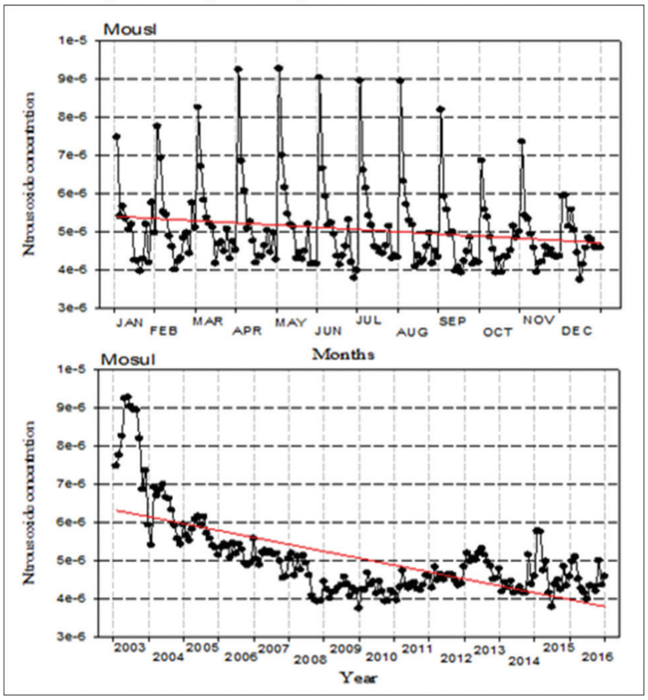


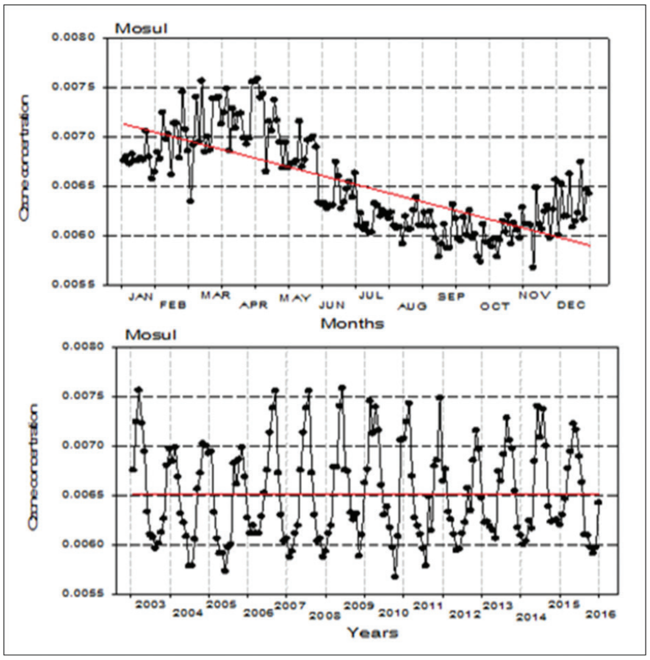
Figure 15: The relationship between ozone concentration and nitrous oxide concentrations for 14 years.

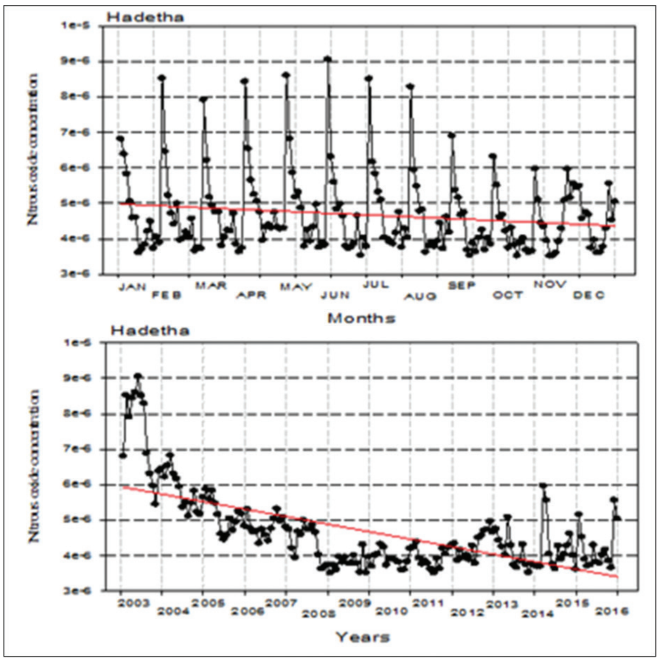
the year 2003-2016. The relationship found between the O_3 and N_2O is positive because the increase in N_2O leads to the increase in O_3 through the troposphere layer. The maximum positive correlation coefficient between (O_3, N_2O) at Nasriyah was discovered to be +0.807, which indicates a strong association because of its dependence on meteorological factors, climatic variations, and geographic location. Concentrations of gases are always highest and closest to their sources and drop as distance or height from these sources increases.

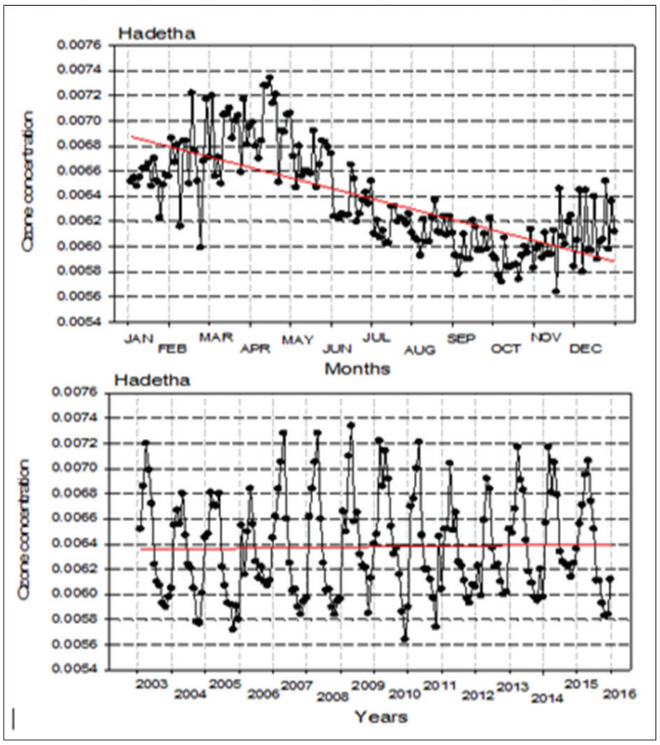
Analysis of the Behaviour of Ozone and Nitrous Oxide Concentrations Monthly and Yearly Mean over Iraq

Figure 16 shows that N_2O was high in Mosul station during Apr and May months, especially, it was the highest value in 2003 and the lowest value in 2016. Also, N_2O was high in Hadetha station during Jun month, especially, it was the highest value in 2003 and the lowest value in 2009. Noteworthily, N_2O was high in Baghdad station during Oct month, and it was the highest value during 2014. N_2O was high in Basrah station during Jan month especially, it was the highest value during 2009. At all stations, there was an inverse relationship through the years. O_3 was high in Mosul station during Apr month, especially, it had the highest value in 2009 and the lowest value in 2016. Also, O_3 is high in Hadetha station during May month, especially, it was the highest value during 2009. O_3 was high in









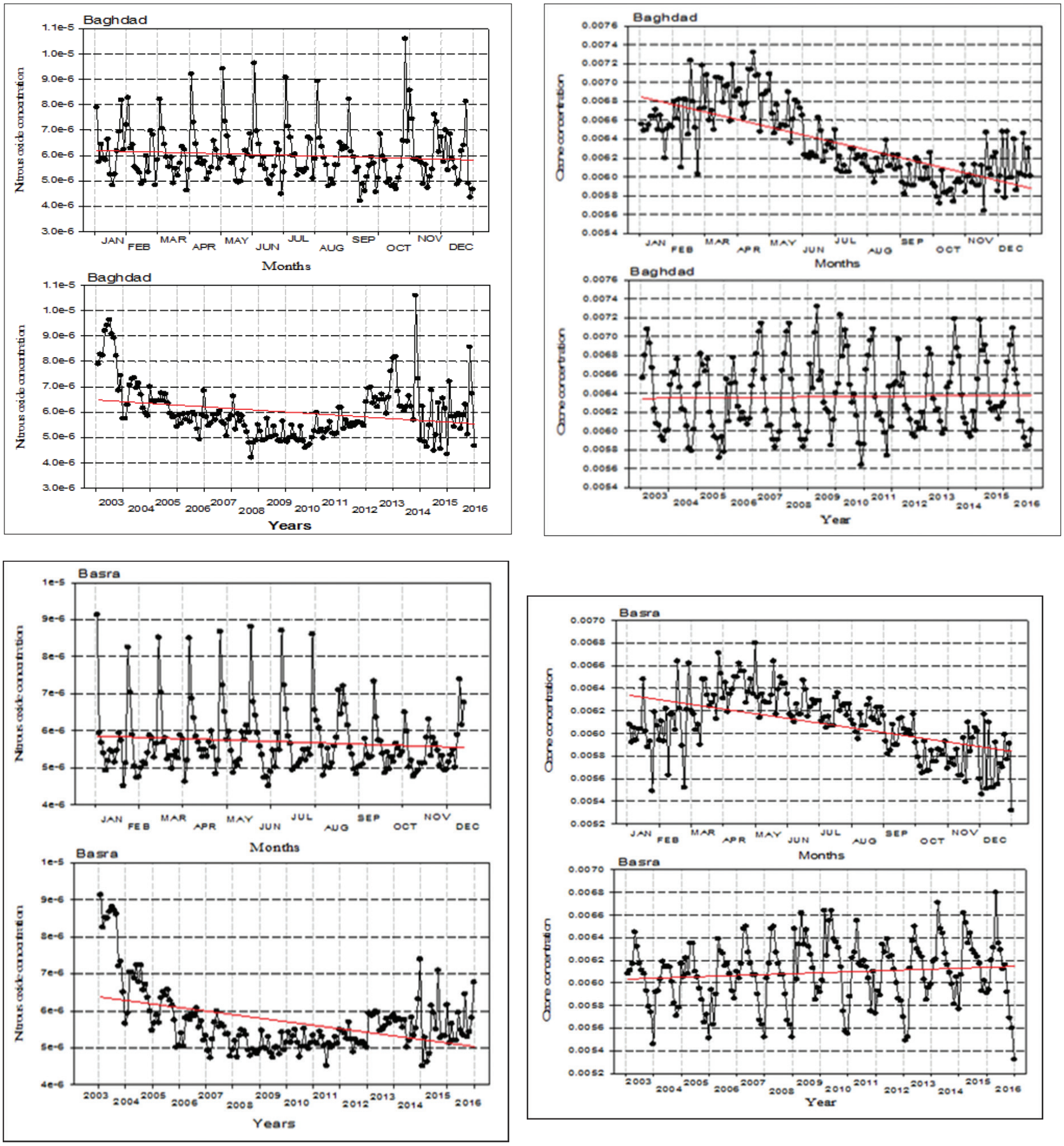


Figure 16: The behaviour of ozone concentrations for a monthly and yearly average in Iraq station for the period (2003-2016).

Baghdad station during Apr month, especially, it was the highest value during 2009. O_3 is high in Basrah station during May month, especially, since it was the highest value in 2015. At all stations, there was an inverse and positive relationship through the years.

Conclusions

It was discovered that the maximum percentage of the correlation between O_3 and N_2O at Nasriyah was +0.807, which indicates a strong association.

This is because meteorological conditions, climatic fluctuations, and atmospheric location all affect correlation. Gas concentrations are always highest close to their sources, and they decrease as one gets farther or higher away from these sources. Due to the migration of stratospheric O_3 from the equator to the north, the northern hemisphere experiences higher levels of O_3, and N_2O in the winter, spring, and autumn seasons and lower levels in the summer and fall. It starts to descend in greater volumes as the pole draws closer. Air from the tropics is redistributed to areas above the tropics in winter when there are slow streams present. The primary source of pollution in major global cities, particularly in industrial cities, is nitrous oxide (N_2O). It severely harms plants, ruins colours and fabrics, and promotes metal corrosion in environments with high nitrogenic acid concentrations. The ozone layer is destroyed by nitrous oxide at high concentrations through the stratosphere layer and the tropospheric layer, the concentration of ozone increases with an increase in the concentration of nitrogen dioxide.

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