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Seasonal Variation Analysis of Tropospheric O_3 and CO over Iraq using AIRS Data During Last Two Decades

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Abstract. Ozone (O_3) and carbon monoxide (CO) have both anthropogenic and natural sources and play key roles in the tropospheric oxidation chemistry. The aim of this research is to demonstrate the monthly distributions of tropospheric CO and O_3 and analysed it is long-term during the years 2003–2021. Over Iraq using the Atmospheric inferred sounder (AIRS) data. The monthly CO time series reveled variance changes and fluctuated, minimum (decreases, Jun and September) and maximum (increases, October and April), these seasonal variations depends on topography and meteorological conditions, the total mean value and standard deviation of CO was ($1208.6\times10^{-10} \pm 230.8\times10$-^{10} ppmv) during study period. The monthly O_3 time series variance between seasons elevated from January until its peak in May and declined from September to October. These O_3 seasonal variations depend greatly on climate changes, meteorological parameters, and location in the atmosphere, the total mean value and standard deviation of O_3 was ($446.4\times10^{-10} \pm76.2\times10^{-10}$ ppmv). The monthly CO values variances among the seasons over five considered selected stations; Baghdad, Mosul, Basra, Kirkuk, and Rutba. The highest CO value was on the northern region (Mosul 510×10-10 ppmv) compared with other stations, and the lowest CO value was in the western region (Rutba; 934×10-10 ppmv). For $O_{3,}$ the highest value was on Mosul (456×10^{-10}ppmv), and the lowest value was in Basra (431×10^{-10} ppmv). The CO results shows negative trends in their annual series over all stations, and the O_3 results shows negative trends at all station except in Basra have significant positive trends.

Keywords: *Seasonal variation, trends, Air pollution, AIRS*

1 INTRODUCTION

The Carbon monoxide (CO) and Ozone (O_3) both are natural and anthropogenic sources play an essential role in the oxidation chemistry of the lower atmosphere [1]. The CO natural sources include chemical production and photochemical non-methane hydrocarbons and CH_4 oxidation, oceanic and biogenic emissions. And the Anthropogenic sources include combustion of fossil fuels and biomass, industrial operations, and motor vehicles [2,3]. The two largest surface sources of CO are fossil fuel combustion and biomass combustion (forest and savanna fires, biofuel usage, and garbage burning). In general, it is reported that roughly a quarter of the CO_2 emissions into the environment come from biomass burning [4,5]. CO is one of the primary air contaminants that can lead to a significant reduction in air quality. It is generally stable, tasteless, colorless, and odorless, and it doesn't irritate anything that breathes it in. which is called the silent killer. However, it is a highly toxic gas whose affinity for hemoglobin is approximately 200 times that of Carbon Dioxide (CO_2) [6]. Furthermore, in relation to the greenhouse effect, it discovered that CO is a crucial indirect greenhouse gas that may influence the global climate. Also, CO may be used to track tropospheric transport processes and plumes [3,7]. The distribution of CO in the atmosphere is influenced by biomass burning, human emissions, transport, and also oxidation through interaction with the hydroxyl radical (OH). It is therefore essential to quantify CO trends in order to comprehend changes associated with all of these components [8]. Uncertainties in the CO budget remain quite high owing to the difficulty in measuring the variability of CO sinks and sources, as well as a lack of emissions statistics and measurements used to generate emissions inventories [4].

The O_3 is one of the most significant and efficient warming gases in the atmosphere. On the ground, it is a pollutant hurts lung tissue, plants, and other living things because it combines strongly with many other molecules to destroy or change them. [3]. It is a secondary pollutant that is not normally released and forms in the atmosphere because of interactions with other pollutants. Most of the time, industries and automobiles generate gases that are the outcome of photochemical interacting between volatile organic compounds VOCS and nitrogen oxides NOx under sunlight which are collectively referred to as "O_3 precursors" [9]. The natural sources of O_3 are including lightning, wildfires, soils, and vegetation. O_3 is a trace gas with radiative properties that exists naturally in the atmosphere. It's playing a significant role in the rate of heating of the atmosphere, and as a result, it has an excellent ability to absorb infrared radiation. [10]. In conditions of strong solar radiation and elevated temperatures, the photochemical reaction rate of precursors is enhanced, leading to an increase in O_3 concentration. In contrast, rain and high relative humidity usually result in a drop in O_3 concentration because of a decline in photochemical production efficiency and an increase in wet deposition. In addition, Wind speed is another element that influences ozone concentration. Normally, increasing wind speed decreases O_3 concentration because high wind speeds are not favorable to the formation of local ozone concentrations [11]. Additionally, atmospheric chemistry, turbulent mixing and surface dry deposition (the primary removal mechanism) all have an impact on O_3 concentration [12]. According to reports, O_3 is a strong oxidant and a significant and important index of photochemical smog, which has been recognized as one of the major pollutants that damaging air quality [13,14]. Stratospheric O_3 is thought to be beneficial for humans and other lives creatures due to it acts as a secure shield by absorbing part of the sun's physiologically damaging ultraviolet UV-B radiation. Increased UV radiation exposure in humans may cause more cases of skin cancer, cataracts, and immune system decline [15].

The oxidation of CO to CO_2 is a crucial mechanism in the formation O3 in the troposphere, and CO has a much extended lifetime than most non-methane hydrocarbons [NMHCs]. The proportional relevance of CO for photochemical O_3 generation is larger in the distant atmosphere [16,17]. Because of the significance of OH as the principal atmospheric scavenger, both O3, the primary OH source, and CO, the primary OH sink, play important roles in troposphere chemistry. As an outcome of photochemistry caused by anthropogenic emissions CO and O3 are occasionally associated in places downstream of significant human source regions [1, 18].

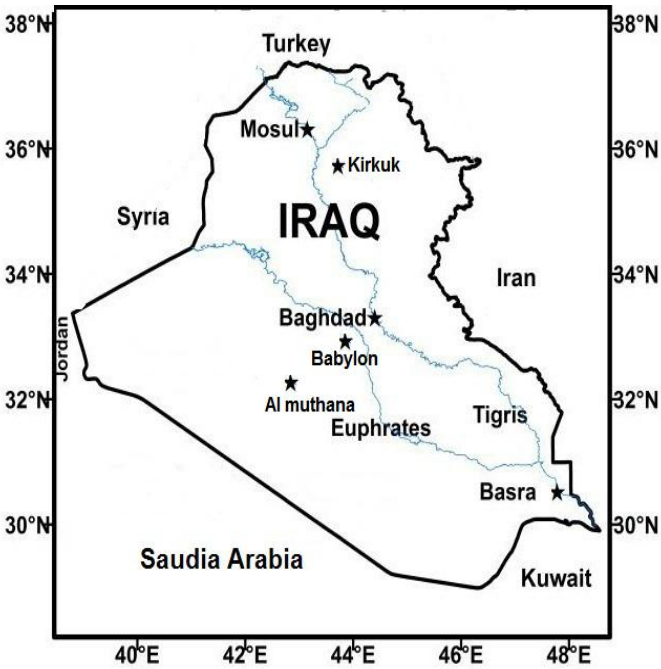
Over the last three decades, scientists have collected data on abundances atmospheric gas and parameter using a wide variety of methods, including balloons, airplanes, and dispersed measuring stations. Despite extensive efforts and high costs, they are unable to provide continuous, extensive regional or global coverage [19]. The remote sensing by satellite supplies high worldwide coverage as well as quantitative data with important temporal or spatial accuracy, and it boosts the researcher's capacity to fully understand the impact that Human behaviors have on the chemistry structure of the atmosphere and changes in climate [5]. It is essential to keep record of and monitor the variations in the concentrations of gases as a way to better acknowledge and evaluate the role The alterations play in climate change, as well as to acquire more accurate and far-reaching estimates [20-25]. Iraq, like other developing nations, does not have a suitable technique to monitor such emissions because of the high costs involved in spreading out the systems for monitoring the ground. Only information from outer space, made possible via satellite remote sensing, permit the use of the like measures. These measures cover the whole world well, which increases our capacity to assess the influence that human actions have on Changes in the climate [26]. The Atmospheric Infrared Sounder (AIRS), one of numerous instruments aboard the Earth Observing System (EOS) Aqua satellite, launched on May 4, 2002, was the first of the first generation of advanced meteorological sounders for operational and research usage [27-28]. With AIRS observations, spatial and temporal changes in CO and O_3 emission able to investigated directly and independently from other methodologies across an abundance of locations. The aim of this study to analyze the monthly distributions of tropospheric CO and O_3, analyze their long-term trends for the entire study period of 2003–2021 over Iraq, using the returned AIRS Level 3 Monthly Products (AIRX3STM) Data Version 6, this includes 58 grid points' worth of data covering the whole of Iraq. Also, the satellite information was evaluated over five stations; Baghdad, Mosul, Basra, Kirkuk and Rutba.

2 MATERIALS AND METHODS

2.1 Study area and weather situation

The region under study is Iraq, as shown in figure (1), in south-western Asia and mostly covers up the Plain of Mesopotamia, between latitudes 29° and 38° N and Longitudes 39° and 49° E (a small area lies west of 39°). Iraq shares borders with Iran located to the east, Turkey is located to the north, Syria is located to the northwest, Kuwait and Saudi Arabia are located to the south, and Jordan is located to the southwest [29]. It covers 437,072 km^2 and is the 58th largest nation in the world. The Northeastern areas are mountainous, central and southeast regions are arid plains, western and southwest regions are deserts, and the uplands between the Euphrates and Tigris rivers are undulating. These two large rivers pass across the center of Iraq, moving from northwest to southeast over lush grassy lands.

Iraq's north is largely mountainous, with the highest mountain peak standing at 3,611 meters (11,847 feet). There is a 58-kilometre stretch of coastline in the northern Arab Gulf [30]. The entire country been divided into two distinct regions by eighteen governorates. The governorates of Duduk, Erbil, and Sulaymaniyah are situating in a federal area in the north of Iraq, with fifteen additional provinces in the south and center of the country. The overall area of Iraq's farmland estimated to be 115,000 km^2 but around 26 percent of the entire area. The remaining ground is unsuitable for farming, and most of the land along the northern line between Turkey and Iran is forests [31]. The climate of Iraq classified as semi-dry. In the summer, the temperature on average in Iraq is (50°C), whereas in the winter, the average temperature is (0°C). With an annual rainfall rate of "100-180 mm" and the majority of precipitation falling between the months of December and April, the mountainous area in northern Iraq gets more rainfall than the regions in the center and south of the country [32, 33].



Fig, 1. The geographical feature of study area.

Rainfall is more prevalent in the highlands, reaching up to 1000 millimeters per year in certain locations, although the topography prevents widespread agriculture. Agriculture on unirrigated soil is mostly restricted to mountain slopes, hillsides, and steppes, which get (300 mm) more precipitation each year. In the winter, mean minimum temperatures vary from near zero (only before sunrise) in the northern and northeastern foothills and the western desert to 2 to 3oC and 4 to 5 °C on the delta plains of southern Iraq. In the western desert and northeast, it reach about 16 °C, while in the south, they reach 17 °C. In the summer, the record low temperatures vary between 27 to 34 °C and maximum temperatures range from about 42 to 47 °C. Sometimes, the temperature is descends below freezing and have reached 6oC near Al-Rutba in the southwest desert. They are almost certainly to exceed 49 degrees Celsius when the weather warms up in the summer, and some sites had recordings of temperatures exceeding 53 degrees Celsius.

The summertime distinguished by two types of wind occurrence. The sharji is a dry, dusty wind that sometimes comes in gusts and blows from April to the beginning of June and again from late September to the beginning of November. It may just last a day at the start and conclusion of the season, but it might linger on multiple days at different times. This wind frequently blows, followed by intense dust storms that can reach up to a many thousand meters high and shut down airports for a short time. The shamal is the name for the wind that blows most of the time from the middle of June to the middle of September. A steady wind only goes away a few times during this time. This shamal brings very dry air, which lets the sun heat the land's surface very quickly, but the prevailing breeze does have some effect of cooling. Because it does not rain much and it's very hot, a large portion of Iraq is desert. Earth and plants rapidly lose the little water they get from rain due to very high rates of evaporation. Without a lot of watering, plants would die. Even though some places are dry, they do have wild plants, unlike the desert [26 and 31].

2.2 Data sources and methodology

Five stations were chosen in Iraq; Baghdad, Mosul, Basra, Kirkuk and Rutba (Fig. 1) these stations were selected in order to monitor the concentrations of CO and O_3 during 19 years (2003-2021). AIRS data were used to do the work, and then these data were transformed into monthly rates to demonstrate the influence of seasons. Excel was used to do processing and tabulations on the data. In order to evaluate and investigate the changes in the concentrations of CO and O_3 in the troposphere, two steps were used to analyses the data: the first step was to analyses the monthly time series of CO and O_3, and the second step was to analyses the long-term trends of CO and O_3 over the area of study for the interval between 2003 to 2021. Both of these analyses were performed using the data collected for the interval between 2003 to 2021. The AIRS devices provided CO and O_3 level 3 (L3) monthly products (AIRX3STM) version 6 measurements aboard Aqua Satellites can utilize to analyze and estimated CO and O_3 variations all over Iraq. In recent years, remote sensing from satellite has been used to monitor CO and O_3 with a high temporal and spatial coverage. This may compensate efficiently for lacking of surface observational measures that have been collected [32].

The AIRS represent a one of the devices on the Earth Observing System EOS, which is on The Aqua Satellite of the NASA in a polar orbit at an elevation of 705 km. It has broad global coverage, a scanning of many tracks at once spread of 1650 km, and a spatial resolution field of view FOV of 13.5 kilometers at nadir. It established on May 4, 2002. AIRS is a sounder that can scan over several tracks that operates constantly and consists of a telescope that supplies a scale spectrometer [21,35]. The AIRS, along with its two accompanying microwave devises, the Advanced Microwave Sounding Unit (AMSU) and the Humidity Sounder for Brazil (HSB), comprise the integrated Sounding Device for the Atmosphere. These sensors distinguish and observe the vertical structure of the atmosphere, from the ground to space [33]. The scientific aim of the AIRS/AMSU/HSB is Operational numerical weather forecasting is essential for understanding climate dynamics, determining the elements that drive the energy and water cycles that operate on a global scale, and investigating interactions between the atmosphere and the surface. Moreover, these instruments designed to operate in synchronism with each other [15, 37].

generally, 228 monthly ascending L3 granules were retrieved to get the outcome that was required. The files for the AIRX3STM V6 product obtained from the AIRS site and stored as HDF-EOS4 files. This is a beneficial file extension due to allow it easy to collect out data and MS Excel used to put it in a table. The monthly data is in a file called Hierarchical Data format (HDF), which shows the time and position along the satellite's pathway. The CO and O_3 observations were from ascending orbits with an accuracy of 1°×1° (latitude longitude). In addition, many beneficial programmers, such as Microsoft Excel, Sigma plot 14.5, and Statistical Package for the Social Sciences (SPSS) 26, were used to cover the data processing and mapping the data. Sigma plot, which is a suite of scientific programmers for charts and data analysis used for creating time series charts and long-term trends for each CO and O_3 and determine out the slope of regression, was used to reveal these values from various months and areas for comparison. Then, using SPSS, do an analysis of the obtained datasets to determine the statistical values of selection parameters, Photoshop was used to editing the graphics.

3 RESULT AND DISCUSSION

3.1 Descriptive analysis

Summary of results of CO and O_3 concentrations spanning the years (2003- 2021) over study area obtained from five monitoring stations; Baghdad, Mosul, Basra, Kirkuk and Rutba are presented in table 1 showing, minimum, maximum, mean values, standard deviation and trend. The monthly CO mean and standard deviation were (1208.6×10^{-7} $\pm230.8\times10^{-7}$ ppmv) for the study period. The CO is experiencing different seasonal fluctuations at various seasons depending on the atmospheric factors and topography. The highest concentration of CO was on northern of Iraq (Mosul) (510×10^{-7} ppmv) compared with other stations, and the lowest concentration of CO was on western Iraq (Rutba) (934×10^{-7} ppmv). The highest mean monthly of CO was on northern Iraq (Kirkuk) and western (Rutba) (1227×10^{-7} $\pm1222\times10^{-7}$ ppmv) respectively, and the lowest mean monthly was on the southern (Basra) (1157×10^{-7} ppmv), and the highest standard deviation value in Rutba (220×10^{-7} ppmv). The high value of the standard deviation suggests the level of CO concentration fluctuates from low to high, which means not held at the same level. The monthly total mean and standard deviation of O_3 were (446.4×10^{-8} $\pm76.2\times10^{-8}$ ppmv) across the research period as shown in table 1. The O_3 has different annual fluctuations that depend significantly on climate changes, meteorological parameters, and location in the atmosphere. The concentration of O_3 ranged between (342×10^{-8} $\pm$ 542×10^{-8} ppmv). The highest monthly average was in Mosul (456×10^{-8} ppmv) as well, while the lowest monthly average was in Basra (431×10^{-8} ppmv), and the highest standard deviation was in Mosul station as well, the lowest value of O_3 depending strongly on weather conditions such as rainfall, low temperature, fewer sunshine.

Table 1- The locations and statistical values of CO and O_3 for five stations (Baghdad, Mosul, Basra, Kirkuk and Rutba).

CO concentration (ppv)								
Stations	Latitude (deg.)	Longitude (deg.)	Altitude (m)	Minimum $CO\times10^{-7}$ (ppv)	Maximum $CO\times10^{-7}$ (ppv)	Mean $CO\times10^{-7}$ (ppv)	Standard Deviation $CO\times10^{-7}$ (ppv)	Trend $CO\times10^{-7}$ (ppv/year)
Baghdad	33.32°	44.42°	31.7	0.947	1.44	1.188	0.192	-0.018
Mosul	36.34°	43.13°	223	0.1011	1.51	1.252	0.191	-0.024
Basra	30.50°	47.81°	2	0.956	1.347	1.157	0.151	-0.015
Kirkuk	35.46°	44.39°	331	0.981	1.48	1.227	0.193	-0.017
Rutba	33.03°	40.25°	630	0.934	1.486	1.222	0.22	-0.018
O_3 concentration (ppv)								
Stations	Latitude (deg.)	Longitude (deg.)	Altitude (m)	Minimum $O_3\times10^{-8}$ (ppv)	Maximum $O_3\times10^{-8}$ (ppv)	Mean $O_3\times10^{-8}$ (ppv)	Standard Deviation $O_3\times10^{-8}$ (ppv)	Trend $O_3\times10^{-8}$ (ppv/year)
Baghdad	33.32°	44.42°	31.7	3.45	5.12	4.4	0.59	-0.0015
Mosul	36.34°	43.13°	223	3.42	5.42	4.56	0.74	-0.0019
Basra	30.50°	47.81°	2	3.53	4.91	4.31	0.49	0.0013
Kirkuk	35.46°	44.39°	331	3.46	5.36	4.55	0.71	-0.0026
Rutba	33.03°	40.25°	630	3.49	5.23	4.47	0.62	-0.0019

3.2 Monthly variations

The mean monthly CO during 2003 -2021 over all stations: Baghdad, Mosul, Basra, Kirkuk and Rutba are shown in Fig.2. The seasonal variance in CO concentration fluctuated significantly between the winter and summer seasons. The seasonal variation in the concentration of CO are greatly affected by topography and atmospheric parameters. The highest concentration of CO occurs in winter and spring (February-April), then concentrations decrease significantly and progressive during summer and autumn in (Jun-September) and gradually increase from (October-December), these fluctuations are caused by the seasonal photochemical cycle of hydroxyl radical (OH) in the troposphere, which is responsible for the seasonal dichotomy of CO variations. During the winter and early spring in the Northern Hemisphere, the decline of OH concentrations corresponds with the increase of CO concentrations. The highest CO value was in February in northern Iraq, where it reaches a peak in Mosul (1.510×10^{-7} ppmv) and slightly lower and close in Kirkuk and Rutba (1.48×10^{-7} ppmv) respectively, Because of The spatial nature of areas and the weather conditions , following plumes contributing to CO concentrations come from Turkey and Syria, brought by the Northwesterly winter shamal wind, while the lowest CO values in winter occurred in southern Iraq in Basra throughout the year This decrease in Basra is mostly due to massive marshes in this region of Iraq, along with solar radiation, which increases the concentration of (OH) radicals (the mean CO sink). Then CO concentrations decreases slightly in March and then rises in April, where the peak concentration is observed in western Iraq in Rutba (1.47×10^{-7} ppmv) caused by The spatial nature of areas and the weather conditions. The lowest value for CO occurs in (September) In Rutba (9.43×10^{-7} ppmv). The concentrations increased again from (October-December). The highest values occurred in Mosul, Rutba and Kirkuk (1.31, 1.32, and 1.33) $\times10^{-7}$ ppmv.

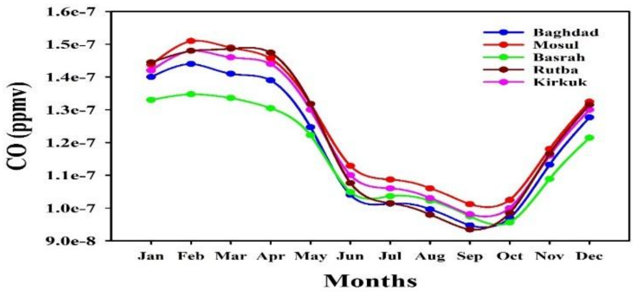


Fig. 2. Time series of monthly average of CO from 2003-2021 for (Baghdad, Mosul, Basra, Kirkuk and Rutba) station.

Fig. 3 shows the monthly O_3 concentrations from 2003 - 2021 for five stations; Baghdad, Mosul, Basra, Kirkuk and Rutba respectively. The O_3 has seasonal fluctuations caused by the geographic character of the locations and climate changes.The concentration of O_3 increases in winter in January until it reaches a peak in the summer in (April-Jun), then it decreases slightly in July, returns and rises in August, then begins to gradually decrease until it reaches its lowest value in December, this seasonal variation is driven by both stratospheric transport and photometaphobic ozone production in the troposphere.

With rising temperatures and longer sunshine hours, the O_3 value reaches it is maximum values occur in summer and spring during (April-September), because of the relatively modest elevation of the temperature as compared to the preceding months , so the highest value of O_3 (5.43 10-8 ppmv) in northern Iraq is in Mosul. O_3 values were at their maximum over industrial and crowded urban areas because of the increased traffic and favourable atmospheric conditions that led to the production of this gas, the lowest value of O_3 observed in (February-September) in southern in Basra . With the decreasing impact of the coldness and the reduction in precipitation rate, as well as impacts of coal and biomass burning, O_3 reduces, the lowest concentration of O_3 occurred in winter and autumn during (October-March) over all stations. The progressive decrease in O_3 concentrations due to a reduction in the average length of sunshine hours each day (4.5 hours) and increased the covering of clouds cover caused by topographic influences. The AIRS data and satellite observations can assess fluctuations in CO and O_3 concentrations in the atmosphere over different places.

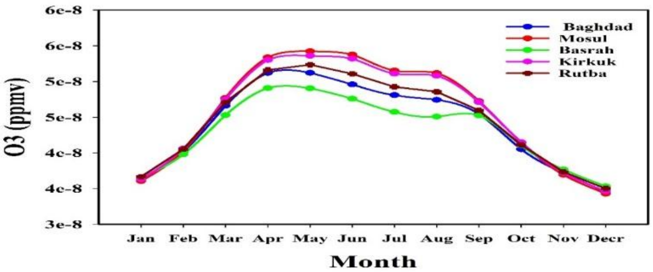


Fig. 3. Time series of monthly average of O_3 from 2003-2021 for (Baghdad, Mosul, Basra, Kirkuk and Rutba) station.

3.3 Trend analysis

The monthly time series of CO and O_3 values had been measured over the station; Baghdad, Mosul, Basra, Kirkuk and Rutba from January, 2003 until December, 2021, as shown in Fig. 4,5. Due to environmental conditions and geographical location, the CO and O_3 emission fluctuate significantly from by season. The values trend analysis of CO and O_3 for these five cities were calculated and summarized in table1. CO trend analyses were calculated for all stations and have significant and progressive decreasing negative trend ranged from (-0.015) to (-0.024) $\times 10^{-7}$ (ppv/year) over (Basra, Mosul), respectively. The trend analysis reveals enhanced in CO value in northern Iraq in Mosul due to the massive amounts of biomass burned in the forest, increasing of incomplete product by consumption of thermal heaters, were used extensively for heating during winter.

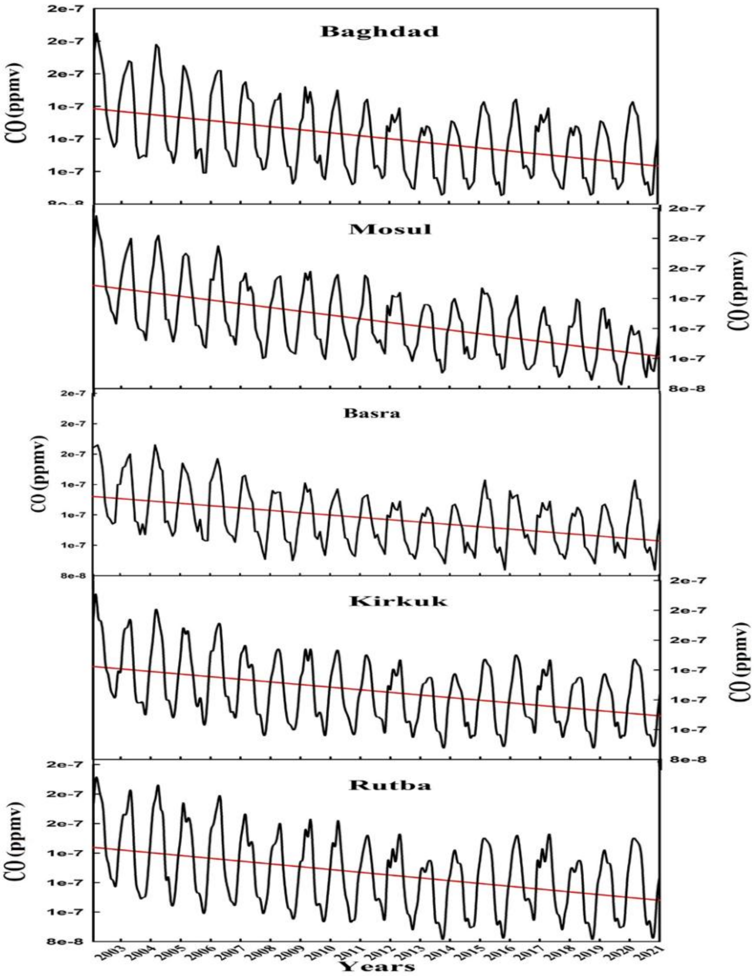


Fig. 4. Monthly trend of CO for the period 2003-2021 for the studied stations.

More research will be required to establish why the concentrations have been significantly descending in recent years. Because to its limited atmospheric lifespan of 2-3 months, CO concentrations are roughly in balance with creation and decay (a false steady state). If the rates of creation or decay fluctuate, the concentration of CO changes rapidly, with no reminder of previous trends in sources and sinks. This opposes with gases that have a longer lifetime, such as CH_4 or chlorofluorocarbons (CFC), which continues to accumulate in the atmosphere long after sources or sinks cease to change or even start to go down. To maintain an ever-heightened concentration of carbon monoxide, either an ever- boosting the source or reducing the removal process is required. In addition, because of their limited lifetime, emissions from one region may not have a significant impact on concentrations or trends in distant regions, particularly in both hemispheres. CO eliminated by reacting primarily with OH in the atmosphere [36]. even though this research does not ascertain What's the value Are reported CO trends due to changes in anthropogenic emissions, it is fascinating to observe the trends reported by Granier et al. (2011) by comparing several global and regional emission inventories.

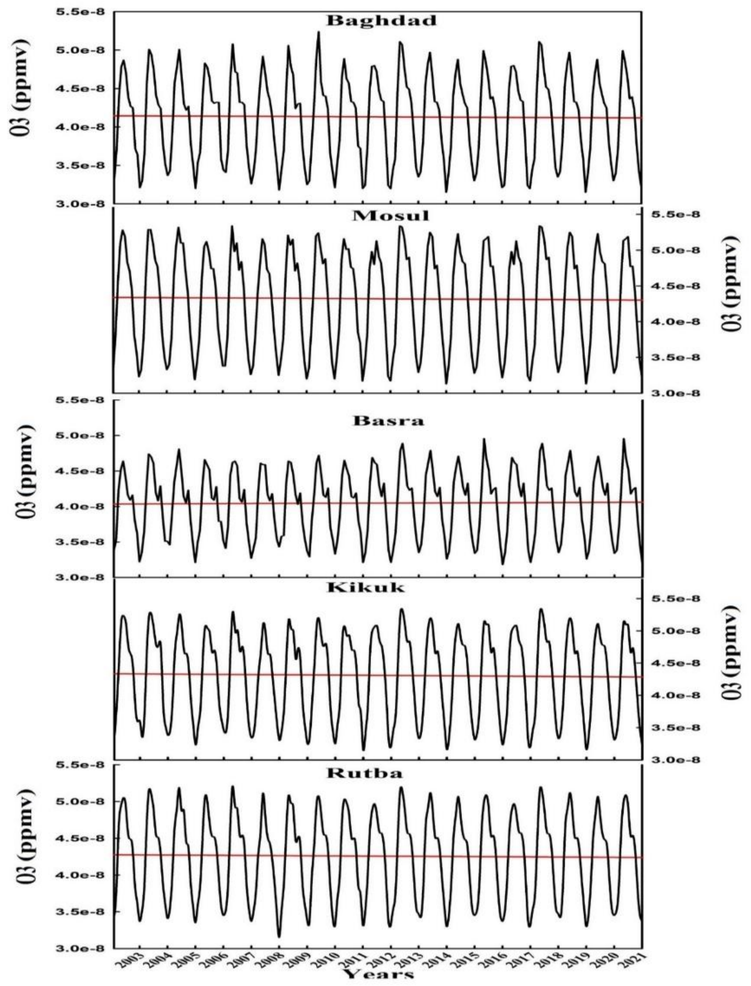


Fig. 5. Monthly trend of O_3 for the period 2003-2021 for the studied stations.

From 1990 to 2010, they indicate a very little decrease in global anthropogenic CO emissions (approximately 1%) with greater reduces for Europe and the United States (3% yr1). Nonetheless, from 2000 to 2010, they reveal growth rates in India (1.5% yr1) and China (3% yr1) [9 and 38]. The annual trend analysis O_3 Shows negative trends at all station except for Basra showed positive trend for entire period. These results are displayed in Table-1, and ranged between (-0.002×±0.0013) $\times 10^{-8}$ ppmv for Basra and Rutba respectively. Basra station presented positive trend compared with other station and followed by Kirkuk station, since increased traffic and favorable weather factors contribute to the formation of O_3, its concentration is consistently greater over industrial and congested cities zones throughout the year. When the gas released in places where it is common to use fossil fuels and the use of air conditioning, Power stations, electricity machines, and industrial facilities produce significant pollutants. that induce the production of tropospheric ozone, High concentrations of ground-based O_3 prevent breathing, exacerbate asthma in those who have chronic asthma sufferers, and harm plants.

4 CONCLUSION

During the previous decades, several causes, such as automobile traffic and informal industrial activity, have had a significant influence on air quality in Iraqi cities, CO and O_3 are important air pollutants that decrease air quality. In this research, we showed the monthly distribution and trend analysis of CO and O_3 over Iraq for 19 years. CO and O_3 display significant seasonal variation, the total mean and standard deviation of both gases was ($1208.6\times10^{-7} \pm 230.8\times10^{-7}$ ppmv) ($446.4\times10^{-8} \pm 76.2\times10^{-8}$ ppmv) respectively During the entire study period, these seasonal changes depend on topographical and weather conditions.

CO shows significant monthly variations, the maximum values was in the months of winter, spring, and the lowest values during the summer and fall. The highest concentration of CO was in February in northern Iraq (Mosul), and the lowest concentration was in western Iraq (Rutba) in September. As for the concentrations of O_3, it varies from one month to another. The highest value was in summer and the lowest value was in the winter, the highest concentration of O_3 was in northern Iraq (Mosul) and the lowest concentration was in the southern Iraq (Basra). From trend analysis of CO and O_3, it was found that the CO values have significant negative decreasing trends for all selected stations during the entire study period ranged between (-0.015 ± 0.024) $\times10^{-7}$ (ppmv/year) over (Basra, Mosul), respectively. Trends analysis of O_3 values ranged between ($-0.002\times\pm0.0013$) $\times10^{-8}$ ppmv for Basra and Rutba respectively, the results showed almost steady negative trends in all stations, except for Basra station, which showed significant positive trends over a period of 19 years. The satellite data effectively displays the seasonal fluctuations in CO and O_3 concentrations. Good consistency found between the contrasting seasonal analysis findings and the AIRS data that obtained. We can get a good idea of how high or low the CO and O_3 values are in various regions by using AIRS data and satellite observations.

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