Journal of Ecohumanism
2025
Volume: 4, No: 1, pp. 2556 – 2565
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i1.6086

The Effect of Ozone Gas Change of Temperature Change Over Iraq

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Abstract

The ozone layer and the ozone gas it carries have become a global issue, and people in different countries of the world are concerned about it due to the dangers it entails and warns of due to its various effects on living organisms on the surface of the Earth, including humans, animals and plants. Given the effect of the ozone layer on temperature rates, which is considered one of the causes of climate change on planet Earth, it has become necessary to know the effect of ozone gas changes on temperature changes over Iraq by analyzing the relationship between ozone gas and temperature rates for selected cities, representing the regions of Iraq, namely Mosul, Kirkuk, Baghdad, Najaf, Wasit, Muthanna and finally Basra. For the period (1989-2022, it represents Iraq's northern, central, and southern regions.The study's objective is to determine the correlation between ozone gas concentrations and temperature rates for every month of the year. It has been discovered that there is a negative (inverse) relationship between ozone gas and temperature rates in all months. Higher temperatures are associated with lower ozone concentrations. Depending on the seasons of the year, the relationship also changed. Our observations indicate that the relationship is weak during most winter months, moderate during many spring and autumn months, and strong to very strong during most summer months.

Keywords: *Ozone Layer, Global Issue, Climate Change, Temperature Rates, Seasonal Variations, Temperature Changes, Living Organisms, and Environmental Effects.*

Introduction

Introduction: The study aims to study the analysis of the correlation relationships between the rates of ozone gas concentrations and the average temperature of the selected stations in Iraq (Mosul, Kirkuk, Baghdad, Wasit, Najaf, Muthanna, Basra) for thirty-three years.

Pearson's correlation coefficient was used to analyze the values of the studied variables to demonstrate their correlation relationships. The following table illustrates how the absolute criterion used in human studies was utilized to clarify the type of relationship.

Table 1. Contains Pearson Correlation Coefficient Indicators That Can Be Used to Determine the Degree and Relationship of the Correlation.

Correlation Coefficient Values	Relationship that is correlated
Less than 2.5	Weak
2.5 - 4.9	Moderate
5 - 7.5	Strong
More than 7.5	Very Strong

Source: Wahib Majeed Al-Kubaisi, Applied Statistics in Social Sciences, 1st ed., Misr Mortada Foundation for Ethnic Books, 2010, p. 41.

The research question concerns whether the alteration of ozone gas influences the variations in temperatures in Iraq. The hypothesis holds that temperature changes in the region are influenced by ozone gas concentrations. The importance of this research lies in the fact that ozone gas acts as a protective shield to the Earth's surface, shielding it from the harmful effects of ultraviolet rays. If these rays reach beyond the Earth's surface, they can have a significant impact on living organisms, including humans. For

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environmental and climatic studies, it is crucial to comprehend the impact of ozone gas on temperature changes.

The study's framework is based on Iraq's geographical boundaries. According to astronomy, Iraq can be found between latitudes 29°5' and 37°22' north and longitudes 38°45' and 48°45' east. Administratively speaking, Iraq is situated in the southwest region of the Asian continent. The borders of this region are Turkey to the north, Islamic Republic of Iran to the east, Jordan to the west, and Kuwait to the south. Syria is bordered by Iraq to the northwest, while Saudi Arabia borders it to the southwest.

The focus of the study is to analyze qualitative changes in stratospheric ozone gas over Iraq. The impact of these changes on temperature variations across different regions of the country is being investigated through analysis.

The correlation between temperature changes and the concentration of ozone gases.

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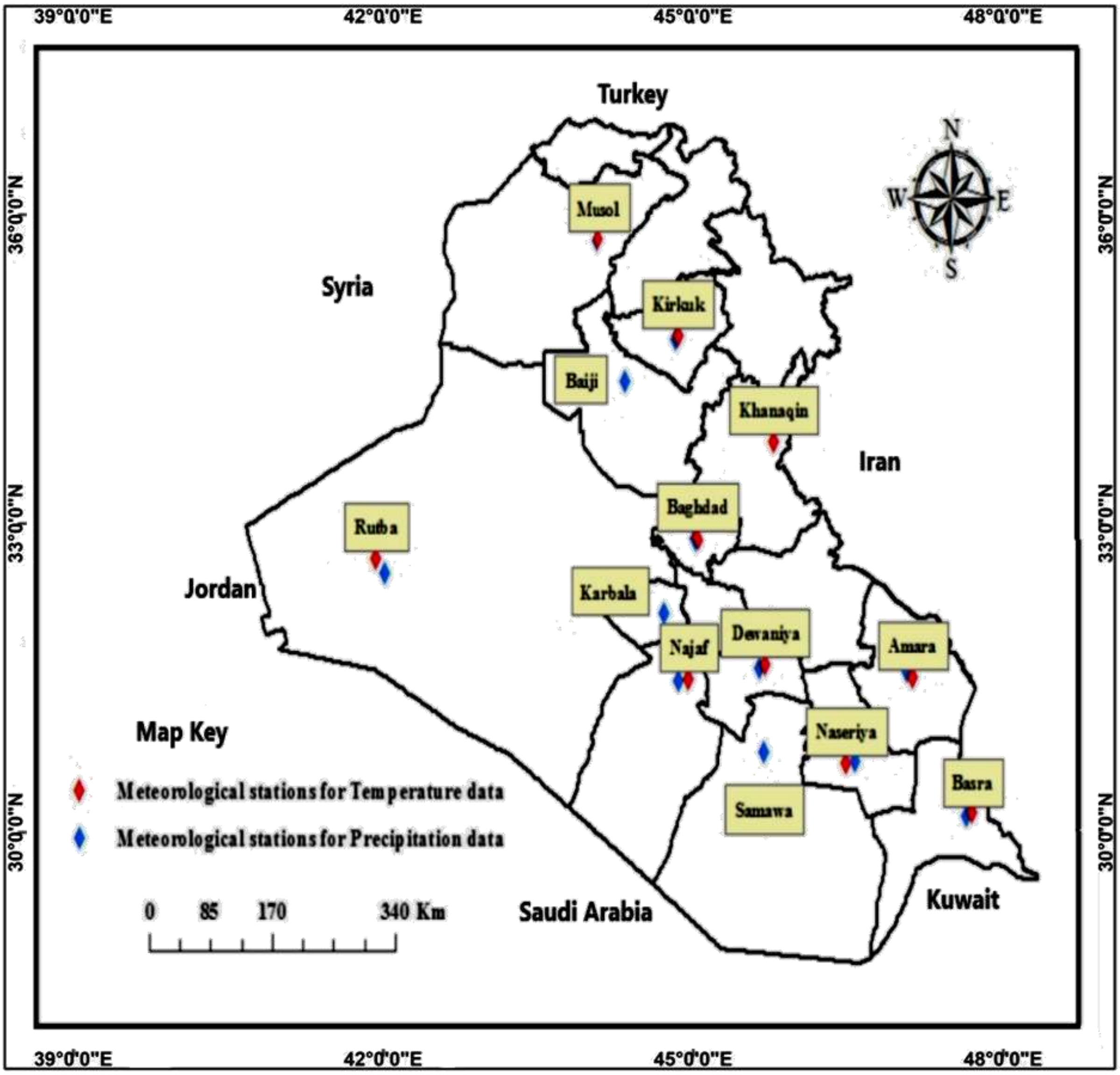
Map (1). The Astronomical and Geographical Location of Iraq and the Locations of the Stations in the Study Area



Source: Based on the world map database in ARCGIS 10.8.

Temperature

Iraq is one of the countries characterized by a high average temperature due to its astronomical location, its distance from the influence of water bodies, its lack of vegetation cover, and the clarity of its sky for most months of the year, which allows the amount of solar radiation reaching the Earth's surface to be greater. A significant portion of Iraq's area falls within the semi-tropical regions and a small portion lies within the warm temperate region. Therefore, this location is a basic factor in controlling the thermal condition due to the angles of incidence of solar rays and their angles of inclination, as temperatures rise in the summer months in most of the stations included in the study due to their locations in relation to the latitude circles and their height above sea level (Saud Abdul Aziz Al-Shaaban, 1996, p. 39).

The thermal characteristics in Iraq are the result of a combination of a group of different climatic factors and controls that result in differences in their seasonal and annual distribution, most notably the location in relation to the latitudes that accompany the difference in the angles of solar radiation and then the thermal energy reaching the surface of the Earth.

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The characteristics of height, depression and extension also affect the general path of temperatures, in addition to the effect of proximity and distance from water bodies on temperatures and their differences, as they increase in height in areas far from them and vice versa, in addition to the moving pressure systems and the air masses that accompany them, which vary in their characteristics, in Terms of their effects on Iraq, as well as the effect left by the air depressions and the different air masses whose effects reach all regions of Iraq (Abdul Imam Nassar Dery, 1988, p. 40).

Amal Saleh Aboud and Abdullah Salem Abdullah define temperature as the feeling of cold or hot, which is the energy that can either be felt through touch or measured by thermometers. 86), and the characteristics of temperature vary temporally in its annual, monthly and daily chores, depending on the apparent movement of the sun and specifically the angle of incidence of the sun's rays and the length of the day. The average temperature was used in this study by extracting the average after collecting the minimum and maximum temperatures for all study areas.

Global Warming and Ozone

It has been confirmed by global studies that the deterioration of the Earth's climate is not new, and it is caused by the rising concentrations of greenhouse gases, and Iraq is not exempt from this phenomenon. It is evident from the download of climate data in Iraq that all climate elements have experienced a negative change. The average temperature has gone down significantly over the past fifty years. The ozone layer has been demonstrated by climate scientists to have a significant impact on weather systems throughout the hemisphere, with particularly pronounced effects during the summer months.

There are many climatic elements that are affected by the variation in ozone concentration, and there is a variation in the values of climatic elements from one place to another and in all climatic cycles in the study area, and atmospheric ozone plays a major role in influencing these climatic elements.

Ozone in the atmosphere has two effects on the Earth's thermal balance: it absorbs ultraviolet solar radiation, which heats the stratosphere (the upper layer of the atmosphere), and it also absorbs infrared radiation emitted from the Earth's surface, effectively trapping heat in the troposphere (the lower layer of the atmosphere). According to NASA Arabic, n.d., the climatic effects of changes in ozone concentrations vary depending on the altitude at which they take place.

Climate change is the main environmental challenge caused by the ozone hole. A significant correlation has been found between the ozone hole and atmospheric weather systems across various regions of the Southern Hemisphere, particularly during the summer months, according to recent studies by climate scientists. Polar wind currents have been intensified and displaced southward due to the depletion of the ozone layer. As global temperatures continue to rise, Antarctica's cold temperatures are being preserved by these strengthened winds. This phenomenon leads to the acceleration of ice melting and the increase in sea levels.

A cooling effect on the surface of the Earth is caused by the significant depletion of ozone in the lower stratosphere, which is primarily caused by chlorine and bromine gases produced by humans. A warming effect on the Earth's surface is amplified by the anticipated increase in ozone concentrations in the troposphere due to surface-level pollutants, which is a consequence of the anticipated increase in ozone concentrations in the troposphere. The melting of polar ice and the rise in sea levels are both accelerated by these contrasting phenomena, which not only affect global temperature patterns but also increase the impact of climate change.

When compared to other atmospheric gases, the impact of changes in ozone levels is particularly significant (Mario J. Molina, Frank S. Rowland, 1974, pp. 491–491). In particular, the depletion of ozone contributes to global warming intensifying the variability and rising temperatures of the global climate, primarily due to the accumulation of greenhouse gases, especially carbon dioxide.

Several gases responsible for ozone depletion, such as chlorofluorocarbons (CFCs), also act as greenhouse gases. These substances trap infrared radiation emitted from the Earth's surface, thereby contributing to the warming of the planet. Conversely, climate change has a reciprocal influence on the ozone layer, as shifts in meteorological conditions and atmospheric structure induced by climate change directly affect ozone behavior.

One of the primary concerns is the anticipated cooling of the stratosphere as a consequence of climate change. This cooling is expected to extend the conditions favorable for chlorine-induced ozone depletion in the lower stratosphere (Mario J. Molina, Frank S. Rowland, 1974, pp. 810–812). Furthermore, the ozone layer is continually being depleted in the upper atmosphere, while ozone concentrations in the lower stratosphere tend to rise during warmer summer temperatures, sometimes reaching levels five times greater than those observed in winter. This phenomenon is particularly evident in regions with significant industrial activity, such as Europe.

Western Japan and the eastern coasts of the United States or northwestern China. In this context, Professor Stefan Bronnimann concluded that the decline in the thickness of the ozone layer in the past not only led to more ultraviolet rays from the sun reaching the Earth's surface and an increase in the Earth's temperature, but also led to a significant increase in the risk of skin cancer in humans (Robert M. Harrison, Christopher D. Holman, 1982, p. 283).

The Montreal Protocol has successfully reduced the atmospheric concentration of controlled ozone-depleting substances (ODSs) and facilitated the recovery of the stratospheric ozone layer. Since the 2018 assessment, the levels of tropospheric total chlorine and bromine originating from long-lived ODSs have shown a continued decline. Recent studies confirm earlier findings, indicating that compliance with the Montreal Protocol has prevented global warming of approximately 0.5–1°C by the mid-22nd century. This estimate contrasts with projections under an extreme scenario of uncontrolled ODS emissions, where increases of 3–3.5% per year could have occurred (Mario J. Molina, Frank S. Rowland, 1974, p. 55).

Measures enacted under the Montreal Protocol have significantly contributed to the restoration of the ozone layer, particularly in the upper stratosphere. Over the Antarctic, the total column ozone (TCO) exhibits signs of recovery, although there are considerable year-to-year fluctuations in the ozone hole's size, intensity, and duration. Beyond the Antarctic region (90°N to 60°S), evidence of TCO recovery since 1996 remains sparse and is associated with low confidence. Projections suggest that TCO levels will return to their 1980 baseline by approximately 2066 over the Antarctic, around 2045 in the Arctic, and near 2040 for the quasi-global average (60°N–60°S). Notably, the global assessment of TCO depletion during the period from 1980 to 1996 remains unchanged from the findings of the 2018 evaluation (Maha Sultan Hajim Sultan, 2015, p. 45).

Radiative processes play a critical role in shaping atmospheric dynamics, as they regulate the energy fluxes entering and exiting the Earth's atmospheric system. This regulation directly influences the energy available for processes such Various atmospheric processes, including air heating, moisture evaporation, and air mass movement, play a significant role in shaping the Earth's atmosphere. Solar energy primarily enters the atmosphere as shortwave radiation, which is subsequently redistributed between the stratosphere and troposphere through specific mechanisms. This redistribution forms the distinctive structural and dynamic characteristics observed in these atmospheric layers.

In the stratosphere, heating occurs in a top-down manner, resulting in higher temperatures at greater altitudes. This temperature gradient stabilizes the layer by minimizing vertical mixing, as denser air is concentrated in the lower levels. The absorption of intense ultraviolet radiation by oxygen molecules, which dissociate during the process, serves as the main source of stratospheric heating. This mechanism is instrumental in defining the stratosphere's distinctive features.

This process leads to ozone formation, culminating in the development of the ozone layer within the stratosphere. Additional warming occurs when ozone molecules intercept and neutralize ultraviolet radiation of slightly lower intensity (UV-B). A significant benefit of these processes is the reduction of

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harmful ultraviolet radiation reaching the Earth's surface, thereby protecting living organisms. Moreover, some stratospheric heating is attributed to ozone absorption of infrared radiation emitted from the Earth's surface.

Conversely, the troposphere follows a different heating pattern. Rather than directly absorbing substantial amounts of solar radiation, the troposphere relies on the Earth's surface to absorb shortwave radiation. The surface then transfers thermal energy to the atmosphere through various mechanisms, including direct surface-air contact and the evaporation-condensation cycle of moisture. The predominant method, however, is the emission of longwave infrared radiation from the surface. This radiation is absorbed by greenhouse gases like water vapor, carbon dioxide, methane, nitrous oxide, and ozone. These gases re-emit part of the absorbed radiation back toward the surface, trapping heat in the lower atmosphere. This phenomenon, known as the greenhouse effect, raises the Earth's average temperature by approximately 33 degrees Celsius, making the planet suitable for life (Abdul Hassan Madfoon Abu Rahil, 2011, p. 66).

The troposphere exhibits a temperature gradient characterized by warmer air near the surface, which cools progressively with altitude. This phenomenon occurs because the surface-heated air, being less dense, rises, while cooler, denser air descends to replace it. The dynamics of this heat exchange are further influenced by the Earth's rotation, surface properties, and temperature variations between the equator and poles. These factors result in a dynamic and turbulent atmospheric layer, where energy and moisture are transported through intricate and ever-changing circulation patterns (Angus Fergusson, 2001, pp. 6, 8, 11).

Since approximately 1980, the stratosphere has experienced significant cooling, largely attributed to ozone depletion and the accumulation of greenhouse gases in the troposphere. In the mid-latitudes of the Northern Hemisphere, the cooling trend has been more pronounced in the middle and upper stratosphere compared to the lower stratosphere. These radioactive processes, while influenced by various factors, are also affected by the presence of potent ozone-depleting substances like CFCs and HCFCs, which are strong greenhouse gases. As a result, the greenhouse effect intensifies, leading to a contraction of the Earth's surface.

While the lower troposphere is warming, the net warming impact of CFCs and HCFCs is counteracted by the ozone depletion caused by these chemicals in the stratosphere. Since ozone plays a crucial role as a greenhouse gas, its reduction diminishes the natural greenhouse effect, thereby cooling the stratosphere. The decrease in ozone concentration also reduces the stratosphere's capacity to absorb ultraviolet (UV-B) radiation, leading to further cooling. Consequently, with fewer ozone molecules absorbing UV radiation, a larger proportion of this radiation reaches the Earth's surface.

The warming of the Earth's surface and the lower atmosphere is influenced by various factors, including the increased presence of greenhouse gases (Angus Fergusson, p. 8). These gases amplify the downward flow of long-wave radiation while reducing its upward flow, resulting in a warming effect on the troposphere and a cooling effect on the stratosphere. The impact of specific greenhouse gases on the stratosphere varies significantly, depending on the altitude at which they alter upward emissions. For instance, carbon dioxide exhibits the most substantial cooling effect on the stratosphere, whereas chlorofluorocarbons (CFCs) contribute to warming in this region. Despite these individual variations, the collective increase in greenhouse gas concentrations ultimately leads to a cooler stratosphere.

This cooling of the stratosphere has critical implications for ozone depletion. Low temperatures facilitate the formation of polar stratospheric clouds (PSCs) during the sunless polar winters in the lower stratosphere. These clouds enable chemical reactions that convert stable chlorine and bromine compounds into reactive forms. When sunlight returns to the polar regions in spring, these reactive chemicals trigger rapid ozone depletion, contributing to the pronounced ozone losses observed in these areas.

Global measurements and computer modeling have been used to study the effects of ozone depletion and heightened greenhouse gas levels. The findings suggest that while the Earth's surface experiences warming primarily due to increased greenhouse gas concentrations, the middle and upper troposphere shows

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minimal temperature changes. Conversely, the stratosphere undergoes significant cooling, primarily driven by ozone depletion (Angus Fergusson, p. 11)

The increase in temperature by 0.5°C in Western Europe, 0.41°C in the United States, 1.23°C in Russia, and 1.3°C in Eastern Siberia is an indication that there are factors (natural and human) contributing to the rise in global temperatures and climate change (Peter D. Jones, 1998, pp. 544–545). In general, the average global temperature has increased by 0.74°C in the past year, in addition to the fact that the rise in minimum temperatures and winter temperatures is faster than the rise in maximum temperatures and summer temperatures (Intergovernmental Panel on Climate Change (IPCC), 2013). Scientists anticipate that the average temperature will rise by (1.5–4.5) °C during the next 40-60 years, as it is one of the most significant changes accompanying the increase in greenhouse gases.

Second: The correlation between ozone gas and the average temperature in the study area.

The correlation theory reveals the strength of the relationship between two variables, which can be utilized to determine the type of relationship between phenomena, like the relationship between education and performance. The main objectives of correlation analysis are to know whether there is a correlation between two variables or a group of independent variables with a dependent variable or the absence of such a relationship (Nabil Juma Saleh Al-Najjar, 2015, p. 33). We take note of the following to study the correlation between ozone gas concentrations and temperatures in the study area:

September

The statistical analysis of the correlation between temperature rates and ozone gas concentrations during September in the study area and the studied climate cycles is shown in Table 2. It is an inverse relationship in all stations, but it differs in the strength of this relationship, which is as follows: It was found that the correlation relationship in the stations (Mosul, Baghdad and Basra) is a strong negative relationship that reached (-0.5) for all stations, and a strong negative relationship also in the Najaf station that reached (-0.6), while the relationship was Moderately negative for the stations (Kirkuk, Wasit and Muthanna) that reached (-0.4).

October

It showed an inverse correlation of ozone gas with temperature rates, but the levels and values of this differed in Wasit and Basra stations, reaching (-0.6), and strongly negative also in Kirkuk and Baghdad stations (-0.5), and moderately negative in each of Mosul, Najaf and Muthanna stations, reaching (-0.4).

Table No. (2). The Correlation Between Ozone Gas Rates (Dibson) and Temperatures (°C) in the Study Area for the Period (1989-2022 Is Significant.

Month	Mosul	Kirkuk	Baghdad	Najaf	Wasit	Muthanna	Basra
September	-0.5	-0.4	-0.5	-0.6	-0.4	-0.4	-0.5
Oct-01	-0.4	-0.5	-0.5	-0.4	-0.6	-0.4	-0.6
Oct-02	-0.5	-0.4	-0.6	-0.4	-0.5	-0.4	-0.7
Dec-01	-0.1	-0.3	-0.1	-0.4	-0.2	-0.1	-0.2
Dec-02	-0.1	-0.4	-0.1	-0.2	-0.1	-0.2	-0.3
February	-0.2	-0.1	-0.2	-0.1	-0.1	-0.2	-0.2
March	-0.5	-0.5	-0.4	-0.5	-0.5	-0.7	-0.7
April	-0.4	-0.4	-0.4	-0.6	-0.5	-0.7	-0.7
May	-0.5	-0.5	-0.5	-0.6	-0.6	-0.8	-0.6

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June	-0.6	-0.6	-0.7	-0.7	-0.6	-0.8	-0.8
July	-0.6	-0.7	-0.6	-0.8	-0.6	-0.7	-0.8
August	-0.6	-0.7	-0.7	-0.7	-0.7	-0.7	-0.8

Source: The researcher's work utilizes SPSS

November

In Baghdad and Basra stations, there was a significant inverse relationship that reached (-0.6) and (-0.7) respectively, while in Mosul and Wasit stations, there was a significant negative relationship that reached (-0.5) for both. The average negative result for Kirkuk, Najaf, and Muthanna stations was (-0.4).

December

The correlation relationship in Kirkuk and Najaf stations recorded a medium negative relationship of (-0.4) and (-0.3) respectively, while Wasit and Basra stations recorded a weak negative relationship of (-0.2) for both stations, while the stations (Mosul, Baghdad and Muthanna) had a weak negative relationship but to a lesser degree of (-0.1).

January

The relationship in the month of January turned out to be an inverse negative relationship, but its strength varies according to the months, as follows: A medium negative relationship appeared in the Kirkuk and Basra stations, reaching (-0.4) and (-0.3) respectively, and a weak negative relationship in the Najaf and Muthanna stations, reaching (-0.2) for both stations, as well as a weak negative Relationship in the stations (Mosul, Baghdad and Wasit), but to a lesser degree, reaching (-0.1) for all stations.

February

The relationship between ozone gas concentrations and temperatures at the studied stations is in verse, but it differs from one station to another, according to the findings. The correlation at the stations (Mosul, Baghdad, Muthanna and Basra) was a weak negative relationship reaching (-0.2), and the rest of the stations (Kirkuk, Najaf and Wasit) also had a weak negative relationship, but to a lesser degree than the previous ones, reaching (-0.1).

March

Table (2) of the statistical analysis results for the month of March showed that there is an inverse correlation between ozone gas concentrations and temperatures in the study area, but this relationship differs from one area to another, as the stations recorded a strong negative correlation of (-0.7) in the Muthanna and Basra stations, and the correlation was also a strong negative relationship In the rest of the stations (Mosul, Kirkuk, Wasit and Najaf), but to a lesser degree of (-0.5) for all stations, except for the Baghdad station, where the correlation was a medium negative relationship of (-0.4).

April

The correlation relationship varies between weak inverse relationship and strong inverse relationship, as the correlation relationship in the Muthanna and Basra stations recorded a strong inverse relationship of (-0.7) for both stations, and it was also strongly negative and to a lesser degree than its predecessors in the Najaf station, reaching (-0.6), while the Wasit station had a strong Negative relationship and to a lesser degree of (-0.5), while the rest of the stations (Mosul, Kirkuk and Baghdad) recorded a medium negative correlation of (-0.4) for all stations.

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May

The relationship showed a difference in its values from one region to another, as Al-Muthanna station recorded the highest correlation, which was a very strong negative relationship of (-0.8), while the stations (Najaf, Wasit and Basra) recorded a strong negative correlation of (-0.6) for all stations, while the remaining stations (Mosul, Kirkuk and Baghdad) recorded a medium negative Correlation of (-0.5) for all stations.

June

From Table (2), it was shown that the statistical analysis of the correlation relationship in June was negative and its strength varied in the study area, as the Muthanna and Basra stations recorded the highest correlation relationship, which was very strongly negative, reaching (-0.8) for both stations, while the correlation relationship was strongly negative in the Baghdad and Najaf stations, Reaching (-0.7) for both stations. The remaining three stations (Mosul, Kirkuk, and Wasit) experienced a strong negative correlation relationship, but to a less significant degree, reaching (-0.6) for all stations.

July

There was a negative relationship that appeared, but it varied in strength from region to region. The Najaf and Basra stations recorded the highest correlation, which was very strongly negative, reaching (-0.8) in both stations, while the Kirkuk and Muthanna stations recorded a strong negative correlation, reaching (-0.7), while the rest of the stations (Mosul, Baghdad and Wasit) recorded a strong negative correlation, but to a lesser degree, reaching (-0.6) for all stations.

August

The correlation in August was negative, but it varied in strength from region to region, as shown in Table 16. The strongest correlation in Basra station recorded a very strong negative correlation of (-0.8), while all the remaining stations except Mosul recorded a strong negative correlation of (-0.7) for all stations, while the correlation was also a strong negative relationship, but to a lesser degree, in Mosul station, reaching (-0.6).

Conclusions

During most of the studied months, ozone gas concentrations and temperature rates had a negative relationship, with different strengths depending on the station. Most stations experienced a weak and negative relationship during November and December, with Baghdad and Basra experiencing a stronger relationship. The relationship remained negative during January and February, but there was a variance in strength with some stations showing weak to moderate negative correlations.

During March and April, Muthanna and Basra stations had stronger negative correlations, whereas Baghdad and Kirkuk had moderate negative relationships. The relationship increased in May and June, with Muthanna and Basra having the strongest negative correlations and Baghdad and Najaf having relatively strong correlations compared to other stations.

Najaf and Basra had the highest negative correlations in July and August, while the other stations had weaker correlations.

It can be concluded that the correlation between ozone gas concentrations and temperatures in Iraq was mostly negative, with different strengths depending on the season and geographical location. During the summer months (May and August), the relationship was the strongest, but in the winter months (December and February), it was weaker.

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