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Quantification of Atmospheric Black Carbon in Al-Zubair City

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Abstract

The present research commenced in the year 2025 and extended into 2026, during which the city of Al-Zubair was segmented into four stations aligned with the four seasons: spring, summer, autumn, and winter. The levels of black carbon and carbon dioxide were assessed at these four locations during the four seasons. The levels of black carbon at the Shuayba station were recorded as follows:(spring - 4201, summer - 4891, autumn - 3579, winter - 5102 micrograms/m^3). The quantification of carbon dioxide gas levels at the station was (spring-378/ summer-402/ autumn-381/ winter-409 ppm). The findings from the study assessing black carbon at the Al-Burjisia station were (spring-3701/summer-6172/fall-5258/winter-4871), whilst the carbon dioxide measurements yielded (spring-401/summer-378/fall-397/winter-423). The levels of black carbon at the poultry station were (spring-2881/summer-2732/fall-2976/winter-4129). The levels of carbon dioxide gas were (spring-379/summer-361/fall-355/winter-382). The quantification of black carbon levels at the monitoring Al-Khatwa station is detailed as: (Spring-6271 / Summer-4029 / Autumn-5238 / Winter-6672). The levels of carbon dioxide gas were recorded as follows: (Spring-430 / Summer-398 / Autumn-381 / Winter-436).

Keywords

Black Carbon;
Carbon Dioxide;
Atmospheric Pollution;
Air Quality;
Seasonal Variation.

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Introduction:

Air pollution is a critical concern that presents substantial threats to human health and the environment (Assaf & Abdulla, 2023). Black carbon (BC), also known as soot, is a type of air pollution consisting of fine particulate matter (PM2.5) produced by the incomplete combustion of carbonaceous materials, including biomass, biofuels, and fossil fuels (Kouassi et al.,2021; Ahmed et al.,2014). Ambient air pollution comprises a combination of solid, liquid, and gaseous elements, including more than 40 hazardous chemicals from diverse anthropogenic and natural origins (Sicard et al., 2023). Significant quantities of black carbon (BC) are released into the atmosphere due to the incomplete combustion of fossil fuels and biomass incineration (Bond et al., 2013; Liu et al., 2020). Subsequent to emission, black carbon is enveloped by various atmospheric constituents via condensation and coagulation (Liu et al., 2019; Sedlacek et al., 2022).

Photochemical processes are significant for the coating of BC, and the heavily coated BC particles are often internally mixed with secondary inorganic and organic constituents (Wang et al., 2017, 2019; Collier et al., 2018). The most prevalent atmospheric pollutants include particulate matter (PM), black carbon (BC), nitrogen dioxide (NO2), tropospheric ozone (O3), carbon monoxide (CO), and sulfur dioxide (SO2) (Burns et al., 2020). The most prevalent atmospheric pollutants include particulate matter (PM), black carbon (BC), nitrogen dioxide (NO2), tropospheric ozone (O3), carbon monoxide (CO), and sulfur dioxide (SO2) (Prasad et al., 2018). Modern scientific studies and current research indicate that exposure to BC may lead to significant health complications in humans, including non-cancerous respiratory disorders, cardiovascular ailments, and cancer, namely lung cancer (respiratory-related problems, cardiovascular diseases) and cancer (lung cancer) (Ambade et al., 2021). The incineration of agricultural and biological waste, the utilization of coal, oil, and other fossil fuels by humans, and emissions from vehicles have all contributed to a swift rise in the concentration of black carbon aerosols in the atmosphere since the industrial revolution (Zhang and Zhili,2011). Aerosols are tiny liquid or solid particles suspended in the air, generated by both anthropogenic and natural processes (Samudro et al.,2023)

Black carbon (BC), a hydrous aerosol, is a major contributor to atmospheric warming in the region, alongside modifications in atmospheric thermodynamics and altered precipitation patterns. (Lina et al.,2018). Black carbon aerosols considerably influence the climate system through several ways, including the direct absorption of solar radiation (Bond et al.,2013). Mitigating BC emissions could improve air quality in developing nations such as China (Ding et al.,2013).

2: Materials and Methodology.

2:1: Research region.

Al-Zubair is situated in the western part of Basra Governorate, representing a crucial segment of Iraq's oil-producing region. The North and South Rumaila fields and the Burgessia oil field are located in Al-Zubair. These fields generate substantial volumes of crude oil and have several flares for combusting associated gas during extraction, resulting in considerable emissions of gases and black carbon. A study was conducted to quantify carbon levels in the atmosphere of Al-Zubair city due to its substantial population.

The study area was segmented into four regions surrounding Al-Zubair city: the Burgessia region (no.23 on the map) the Poultry region (no. 21 on the map) the Al-Khatwa region no. 14 on the map) and the Eastern Shuaiba region (no. 2 on the map). The measurement intervals were categorised into four seasons: spring, summer, autumn, and winter.

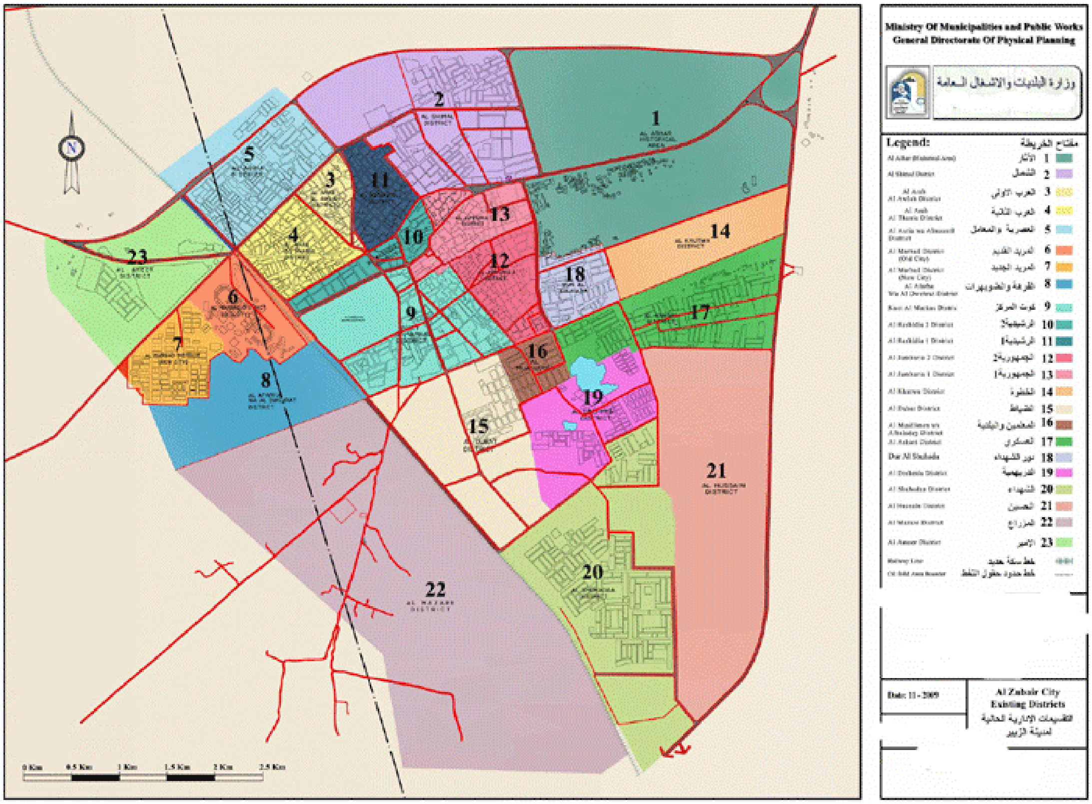

Figure (1) Distribution of Existing Land Uses in Al-Zubair City.

2:2: Advice

2:2:1: Aethalometer advice:

The device activates upon connection to the power supply, initiating the operation process with an automatic inspection of the operating system and the device's physical components. The inspection process lasts thirty minutes, after which the device commences measuring black carbon and displaying the results on an integrated screen. Six readings are obtained by extracting air samples through a small pump at the air inlet point, operating at a flow rate of 2 liters per minute. The flow monitoring procedure is conducted using an internal mass flow meter, which gathers samples on a quartz fiber filter in strip form and does continuous spectrum analysis.

The flow monitoring process utilizes an internal mass flow meter that collects samples on a strip-shaped quartz fiber filter and performs continuous spectral analysis. The Aethalometer employs continuous filtration and optical thermal transition to ascertain black carbon concentration at a wavelength of 880 nanometers, which is the broad spectrum utilized for measurement. The 370-nanometer wavelength corresponds to UV light, as black carbon emits a blue glow, as illustrated by the apparatus (Hansen, 2005).

2:2:2: CO2-100 Handheld Carbon Dioxide Meter | Amprobe.

This apparatus quantifies the concentration of carbon dioxide in the atmosphere. It comprises an LCD panel that exhibits the concentration of carbon dioxide gas. The apparatus is equipped with an alert that signals when the gas concentration surpasses acceptable thresholds. Prior to executing the measurement, we calibrate the equipment to mitigate potential mistakes, subsequently obtaining one reading every five minutes for a duration of three hours. The outcomes are presented on the display.

3: Results:

The study aimed to quantify the levels of black carbon and carbon dioxide at four locations in Al-Zubair to assess the rise in their concentrations utilizing the specified instruments. A schedule was established from 2025 to 2026, comprising four seasons with an average of three iterations per season, yielding the following outcomes.

3-1: Shuaiba Station:

The experiment commenced in June 2025 to 2026 by quantifying black carbon concentrations, doing three measurements per season, and determining the seasonal averages, revealing the peak value in winter and the minimal value in fall.

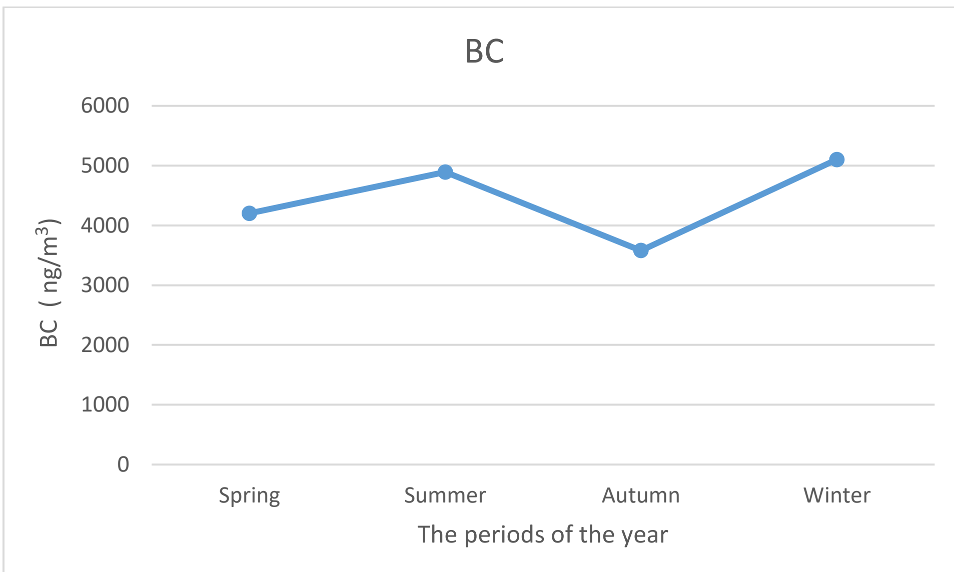

Figure (2) The levels of black carbon during the four seasons in the Al-Shuaiba region are depicted.

The level of carbon dioxide gas in the Al-Shuaiba region was assessed with three iterations for each season, and the mean value was calculated. The outcomes corresponded to Figure No 3. The peak concentration occurred throughout winter, while the minimal concentration was observed in spring.

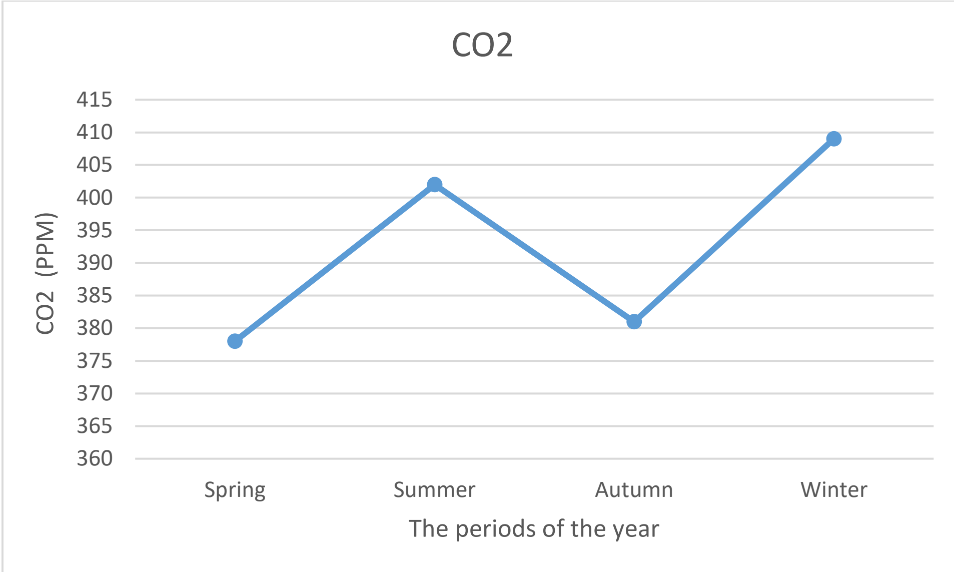

Figure (3) The levels of carbon dioxide gas across the four seasons.

3-2: Al-Khatwa station

Figure (4) presents the black carbon concentration values across the four seasons from 2025 to 2026, indicating that winter recorded the peak level while summer exhibited the minimum.

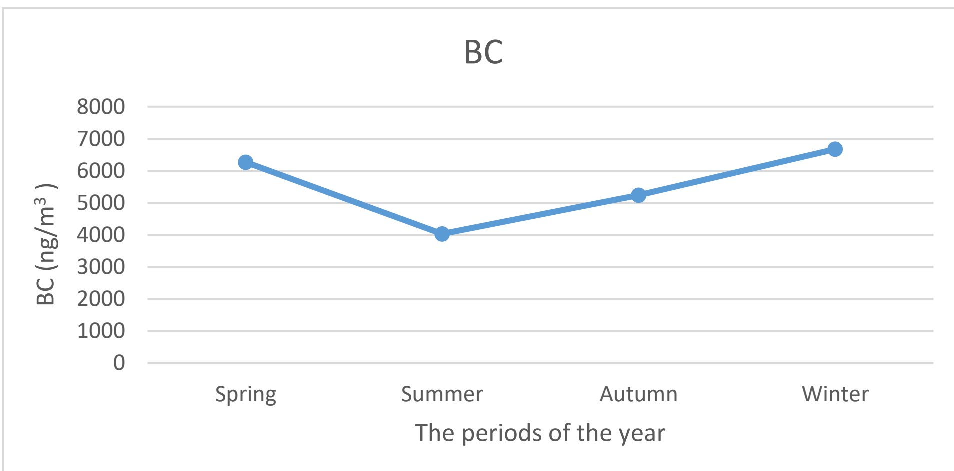

Figure (4) The levels of black carbon during the four seasons in the steppe region are depicted.

Measurements of carbon dioxide gas concentration at the Al-Khatwa station from 2025 to 2026 revealed that winter exhibited the greatest levels, while autumn recorded the lowest, as illustrated in Figure 5.

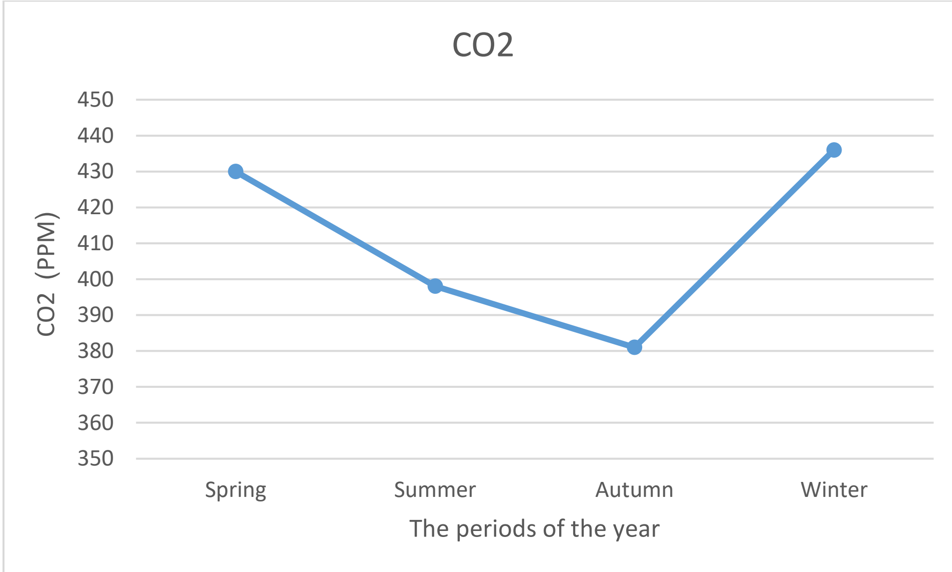

Figure (5) Indicates the level of carbon dioxide.

3-3: Poultry station:

Between 2025 and 2026, assessments of black carbon levels were performed in the poultry sector, revealing that the peak concentration occurred in winter while the minimum was recorded in summer, as illustrated in Figure (6).

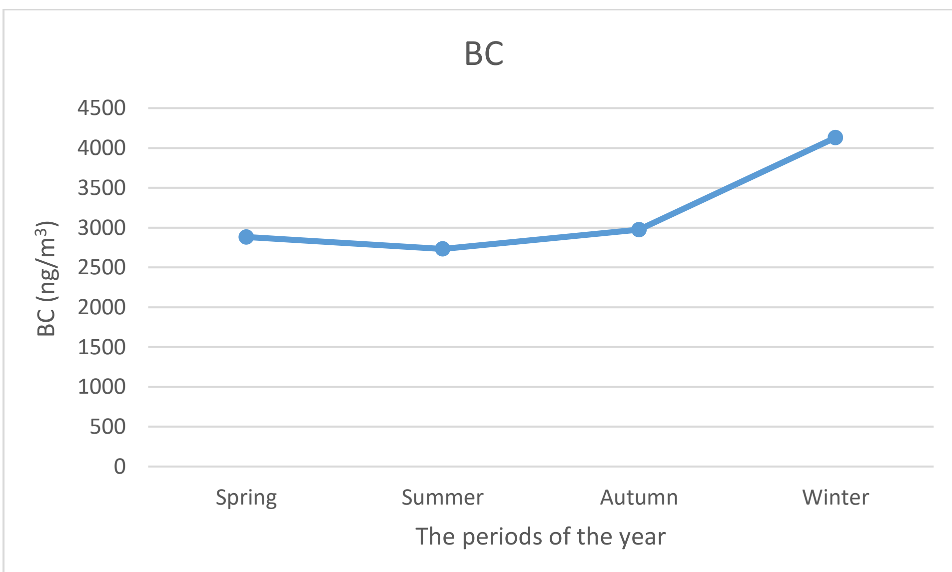

Figure (6) Displays the levels of black carbon in the avian sector.

The figure presented below illustrates the levels of carbon dioxide gas during the four seasons in the poultry region, with winter exhibiting the peak concentration and autumn reflecting the minimum amount.

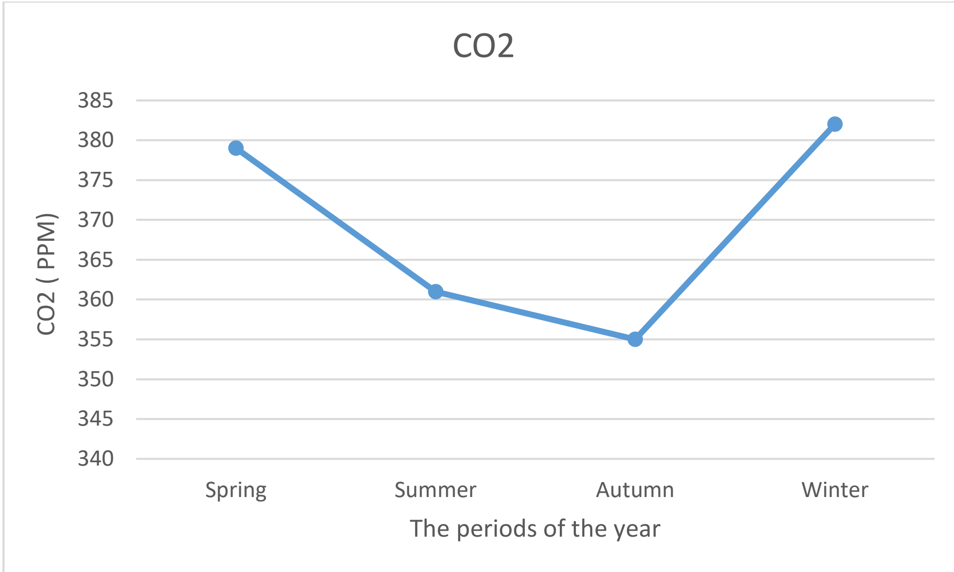

Figure (7) The levels of carbon dioxide in the poultry section are documented for each of the four seasons.

3-4: Al-Burjassiya Station:

The findings illustrated in Figure (8)revealed that the peak concentration of black carbon across the four seasons occurred in summer, while the minimal level was recorded in spring.

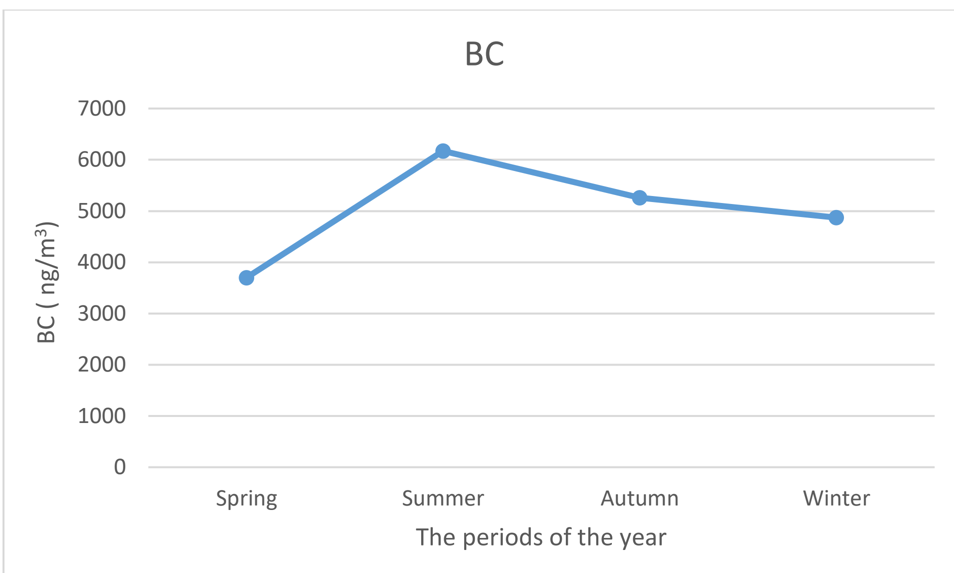

Figure (8) The distribution of black carbon across the four seasons is depicted.

The measurements from the gadget indicated that the peak concentration of carbon dioxide gas occurred in winter, while the minimum concentration was observed in summer.

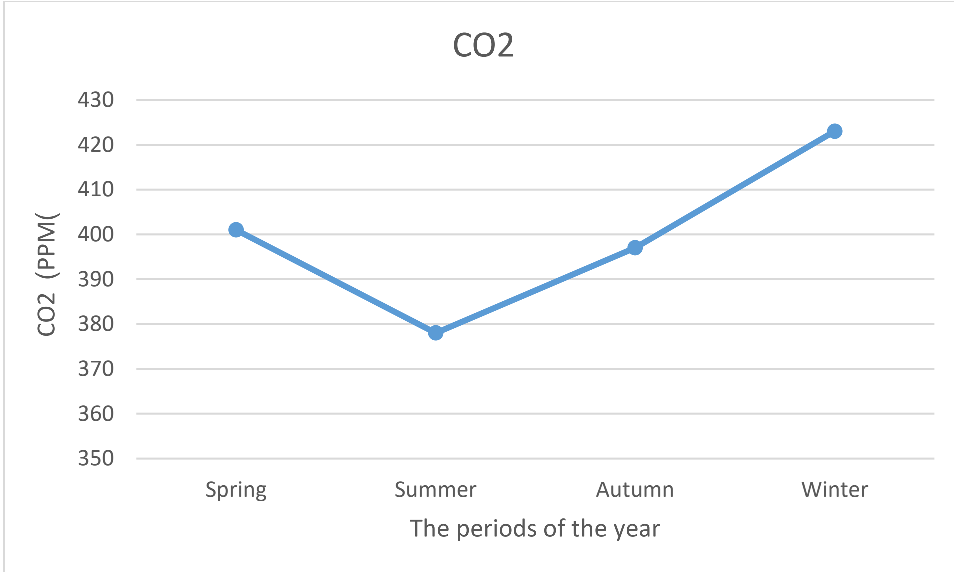

Figure (9) Illustrates the gas concentration across the four seasons.

4: Conclusions:

Al-Zubair and Basra as a whole require annual periodic research to assess different substances, such as particle matter, carbon dioxide, and black carbon. Given that Al-Zubair is encircled by numerous oil facilities in Rumaila and has significant population density, it is crucial to regularly assess black carbon and greenhouse gas levels in the vicinity of Al-Zubair. In addition to an annual study to assess gas emissions such as carbon monoxide, nitrogen oxide, and sulfur oxide, as well as the amount of lead emitted into the air, an experiment will be conducted to determine the concentration of lead in the blood of residents living in areas near high lead concentration zones, such as residential areas near the refinery.

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