Examining the Relationship between Ozone and other Air Pollutants in Al-Hilla City

Ala'a Hamed Emran Al-Husseini
Babylon University , College of Engineering
a_alhussini16@yahoo.com

Abstract

Air pollution must take more attention because its effects on human health. One of the most important air pollutants is ground-level ozone O_3, which plays an important role in air quality and climate change on the earth. Ozone affected by the other air pollutants, so this paper attempt to study the relationship between hourly, daily and monthly ground-level ozone concentration and hourly, daily and monthly air pollutant concentrations and its effect on ground-level ozone concentration. The other air pollutants are: sulfur dioxide SO_2, nitrogen oxides NO_x, nitrogen monoxide NO, nitrogen dioxide NO_2 and carbon dioxide CO_2. The monitoring station is in Babylon University in the south of Al-Hilla city, Iraq for the period 2015-2016. By using statistical analysis, correlation coefficient and some statistics for all air pollutants are computed. Results are: the maximum average ozone concentration is in the summer months June, July and August 39.30 ppb, 45.05 ppb and 36.63 ppb respectively and along the day the peak average ozone concentration is in the afternoon because of high temperature and high solar radiation intensity which is increasing the photochemical activity of ozone. There is no significant correlation between ozone and sulfur dioxide SO_2, carbon dioxide CO_2 ($\rho > 0.05$). High significant correlation is appeared between ozone and nitrogen oxides forms ($\rho < 0.01$). To express the complex relation between ozone and nitrogen oxide forms, proportions such as NO/NO_2 and $(NO_x\text{-}NO)/NO$ is determined which explain the ozone photochemical activity. Ozone concentration decreases with increasing of NO/NO_2 and increases with $(NO_x\text{-}NO)/NO_x$ increasing.
keyword: Ozone, Air pollutants, Correlation coefficient, Optical activity .

الخلاصة

يجب ان ياخذ تلوث الهواء قدر أكبر من الاهتمام بسبب آثاره على صحة الإنسان. احد اهم ملوثات الهواء هو الاوزون على مستوى سطح الأرض O_3، والذي يلعب دورا مهما في تحديد نوعية الهواء والتغيرات المناخية على سطح الارض. ويتاثر الاوزون بملوثات الهواء الاخرى، لذا يحاول هذا البحث دراسة العلاقة بين تركيز الأوزون على مستوى سطح الأرض كل ساعة ،يوم ،شهر وتركيز ملوثات الهواء الاخرى كل ساعة، يوم ،شهر وتأثيرها على تركيز الاوزون. ان ملوثات الهواء الاخرى هي ثاني أوكسيد الكبريت SO_2، اكاسيد النيتروجين NO_x ، اول أوكسيد النيتروجين NO_1 ، ثاني أكسيد النيتروجين NO_2 وثاني أوكسيد الكربون CO_2 . محطة القياس تقع في جامعة بابل في جنوب مدينة الحلة، العراق للفترة 2015−2016. وباستخدام التحليل الإحصائي، يتم حساب معامل الارتباط وبعض الاحصاءات لجميع ملوثات الهواء. النتائج هي: الحد الأقصى لمعدل تركيز الأوزون في أشهر الصيف حزيران، تموز واب 39.30 ppb, 36.63 ppb و45.05 ppb وعلى التوالي، وعلى طول اليوم معدل تركيز الأوزون يبلغ الذروة في فترة ما بعد الظهر بسبب ارتفاع درجة الحرارة وارتفاع كثافة الإشعاع الشمسي الذي يزيد من النشاط الكيميائي الضوئي للأوزون. ولا يوجد ارتباط معنوي بين الأوزون وثاني أوكسيد الكبريت **SO2** ، أوكسيد الكربون **CO2** **($\rho > 0.05$)** . يوجد ارتباط معنوي عالي الدلالة بين الاوزون واشكال اكاسيد النتروجين **($\rho < 0.01$)**. للتعبير عن العلاقة المعقدة بين الأوزون وأشكال اكاسيد النتروجين حسبت النسب مثل **NO/NO2** و **(NOx-NO)/NO** والتي تفسر النشاط الكيميائي الضوئي للأوزون. تركيز الاوزون يقل بزيادة **NO/NO2** ويزداد بزيادة **(NOx-NO)/NO**.
الكلمات المفتاحية : الأوزون، ملوثات الهواء ، معامل الارتباط ، النشاط الضوئي .

1. Introduction

Ozone is a gas or the important chemical component founded in two layers in the atmosphere, it's producing and reacting under the effect of light. Ozone is protecting the earth from UV (ultraviolet) rays. But at ground level, ozone is the main air pollutant. Ozone is affected by the other air pollutants, especially on the sunny days (WHO, 2003 – 2004).

Recently, the changing in climate has given more attention to study the relationship between air temperature and ozone concentration. Studies find out that

the most important factors affecting on surface ozone formation is air temperature. International Panel Climate Change certain that the increasing in air temperature rises the surface ozone concentration (Masoudi *et. al*., 2016)

Respiratory, lung and heart problems are caused mainly by the presence of ozone and other air pollutants such as nitrogen oxides forms NO_x (nitrogen oxide NO, nitrogen dioxide NO_2, and nitrous oxide N_2O) (Masoudi *et. al*., 2015).

The risk of cardiovascular diseases increase with increasing of the concentration of PM_{10} caused by the rapid increasing in the vehicle number every year (Syafei *et. al.*, 2015). Traffic load increasing is increased the concentration of volatile organic compounds (VOCs) which entered in the formulation of ground-level ozone (WHO, 2003 – 2004).

Seasonal variation in ozone concentration is reached to peak in summer (increasing of the photochemical production of ozone), in the other hand, in winter the concentration of ozone is the minimum (Rasheed *et. al.*, 2014).

Emissions of anthropogenic volatile organic carbon, including the non-methane hydrocarbons are the subject in the control program in a lot of states to reduce the concentration of ambient ozone. The major factors affecting on troposphere (ozone concentration) are NO_x and lightning (Saini *et. al.*, 2008).

Ozone air concentration and PM10 are formed the SAB (spontaneous abortion) especially in industrial areas (Ciaulaa *et. al.*, 2014).

The hydroxyl radical OH is controlled the reactions of any compounds in the atmosphere. The first reaction of ozone is the photolysis at short wavelengths < 411nm this reaction is followed by the reaction between ozone and water vapor as follows:

$$O_3 + hv \rightarrow O \quad \ldots 1$$

$$O + H_2O \rightarrow 2OH \quad \ldots 2$$

A small proportion (about 1-10%) of the rounded oxygen is entered in this reaction the remaining is extinguished by an unreactive air molecule. Quickly O_2 formed the troposphere ozone. Hydrocarbons oxides in the presence of nitrogen oxides NO and NO_2 in the atmosphere to form ozone (Kuhlmann, 2001).

The current study attempts to discover the relationship between ground level ozone and other air pollutant and the effect of these pollutants on forming of ground level ozone in order to protect our health and to minimize the pollutants' concentration to an acceptable level, which receives small attention by many researchers in Iraq.

2. Materials and Methods

2.1. Study Area

The monitoring station is in the University of Babylon located in Babylon, Iraq. Babylon University consists more than twenty colleges: arts, engineering, medicine, information technology and economics, law and many scientific and research centers. This University is established in 1991, located at about seven kilometers south of Al-Hilla city (figure (1)), in Babylon governorate. Babylon University students comes from many sites the largest portion of the students number are from the Babylon governorate the others are from Najaf, Karbala, Baghdad, Diwaniyah and Kufa (https://www.northampton.ac.uk/).

Figure (1): The monitoring station in Al-Hilla city.

2.2. Data and Methodology

The database of this study consists of hourly, daily and monthly averages of 6 air pollutant parameters for the period 2015-2016. The air pollution parameters, are ozone, sulfur dioxide SO_2, nitrogen oxide forms NO_x, nitrogen monoxide NO, nitrogen dioxide NO_2 and carbon dioxide CO_2. The measurements used in this study have been carried out by Babylon University monitoring station located in the south of Al-Hilla city and it is operated by the department of Environmental Protection in Babylon governorate, a branch of the Ministry of Environment every 60 minutes daily for each pollutant during the months of the year 2015. The main goal of this study is examining the relationship between ozone and other air pollutants, which influence the behavior of ozone O_3.

3. Result and Discussion

The effect of ozone on human health depends on their old, health state and short or long exposure duration. The levels of outdoor ozone concentration are more than indoor at about 50%. The other factor influence the effect of ozone on human health is the times of the day (WHO, 2003 – 2004). Figure (2) shows the monthly averages concentration of O_3 and other air pollutants for the period of 2015-2016. As seen in figure (2) ozone have the peak value in summer months (June, July and August) this also appear in figure (3), this indicated by WHO report (WHO, 2003 – 2004), other air pollution parameters are vibrated along the year. The react and the influence of ozone is increasing under the presence of sunlight. Table (1) shows some statistics of daily concentrations for study air pollutants, all calculations are done by using Excel and SPSS software programming.

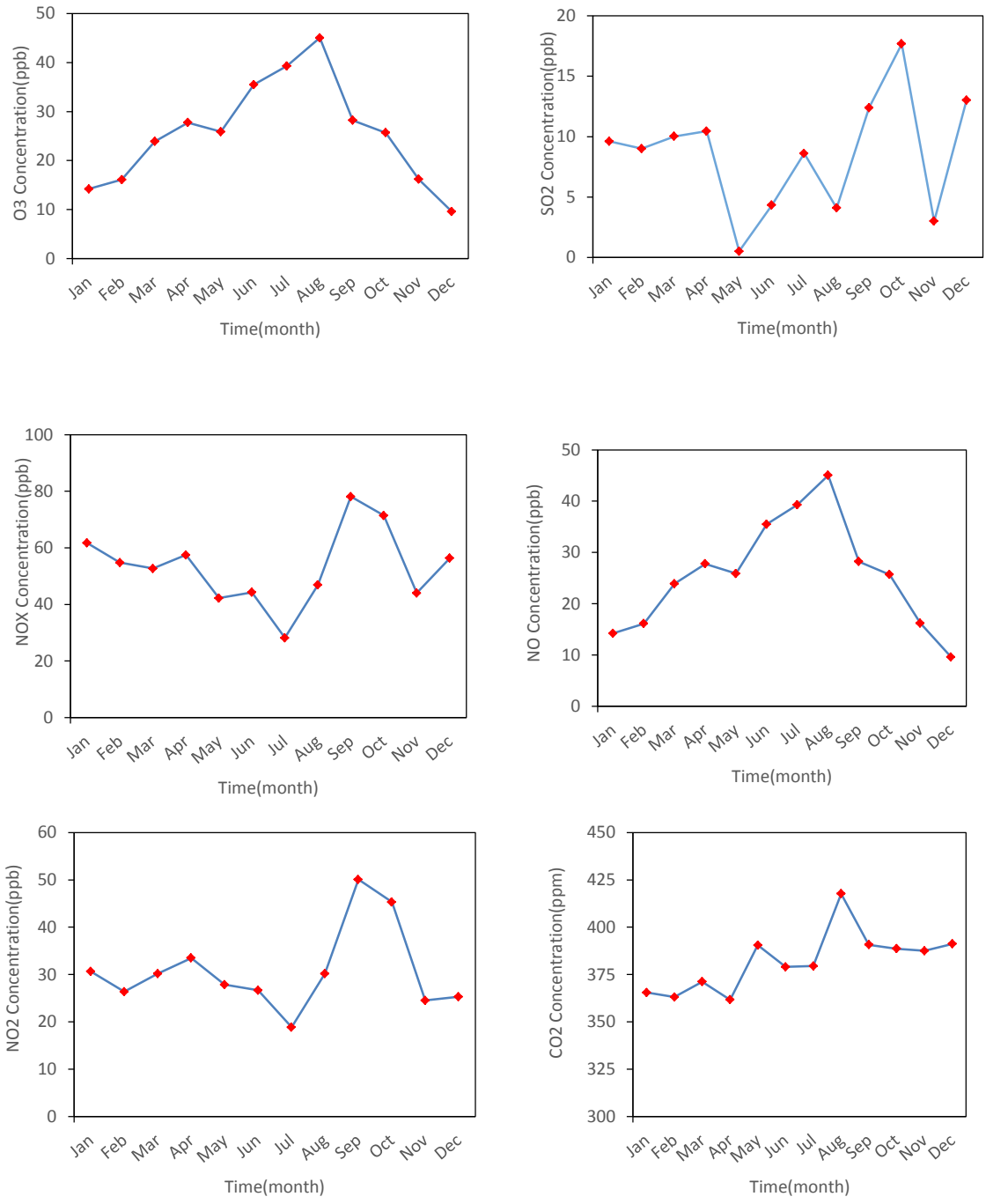

Figure (2): Monthly averages ozone and other air pollutants concentrations values in 2015-2016.

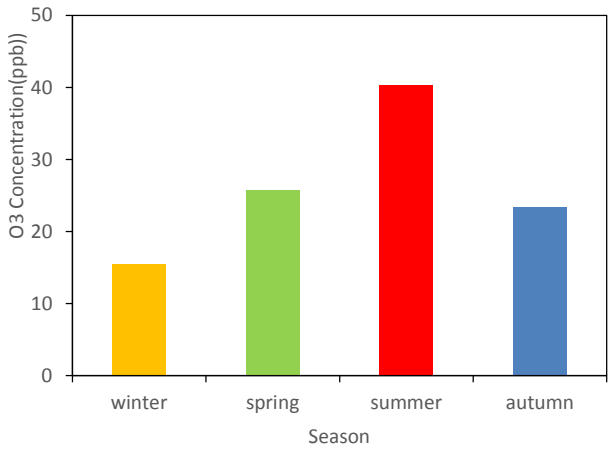

Figure (3): Seasonal average ozone concentration values in 2015-2016.

Table (1): Means and standard deviations of daily ozone and other air pollutants concentrations.

Parameter	Mean	Standard deviation	N
O_3, ppb	25.203	13.042	169
SO_2, ppb	8.459	9.020	169
NO_x, ppb	52.548	28.667	169
NO, ppb	22.390	17.723	169
NO_2, ppb	30.191	17.935	169
CO_2, ppm	373.295	62.081	169

N number of observations.

As shown in table (2), there is no significant correlation between ozone and SO_2, CO_2 ($\rho > 0.05$). High significant correlated between ozone and NO_x, NO because ($\rho < 0.01$). Figure (4) is presented to show daily variations of NO_x, NO and NO_2 with O_3 concentrations,

Table (2): Pearson correlation coefficient between ozone and other air pollutants.

Statistics	SO_2	NO_x	NO	NO_2	CO_2
Pearson Correlation, r	-0.063	-0.300**	-0.370**	-0.119	0.075
Sig. (2-tailed), ρ	0.417	0.000	0.000	0.124	0.333
N	169	169	169	169	169

**Correlation is significant at the 0.01 level (2-tailed). For other numbers correlation is significant at the 0.05 level (2-tailed).

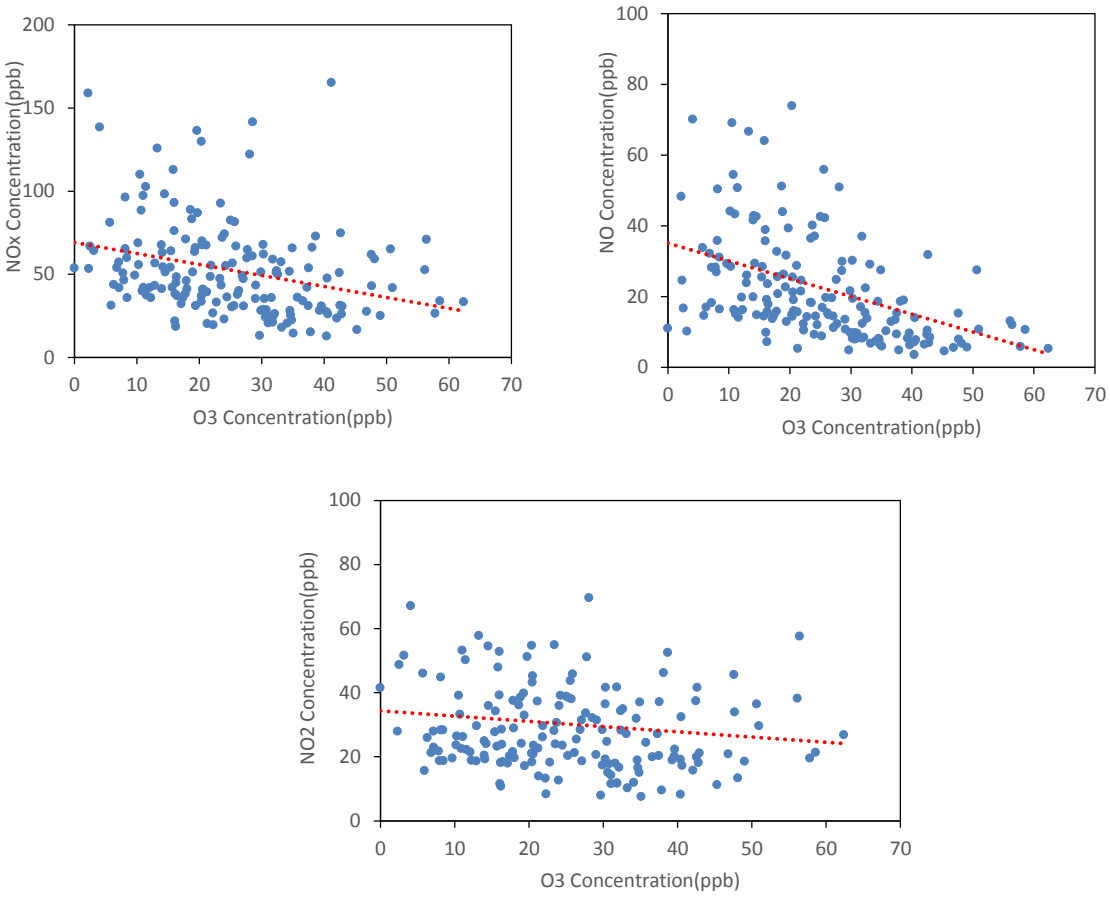

Figure (4): Daily ozone, NO_x, NO and NO_2 concentrations versus in 2015-2016.

3.1 Ozone photochemistry analysis

It is a complex relationship between ozone and nitrogen oxide forms, the reactions between ozone and nitrogen oxides are affected by solar radiation and the presence of volatile organic compounds (VOCs). The reactions which formed ozone in the lower atmosphere are as follows (Masoudi *et. al*., 2016):

$N_2 + O_2 \rightarrow 2NO$ …3
$2NO + O_2 \rightarrow 2NO_2$ $NO + VOC \rightarrow NO_2$ …4
$NO_2 + sunlight \rightarrow NO + O$ …5
$O + O_2 + sunlight \rightarrow O_3$ …6
$O_3 + NO \rightarrow NO_2 + O_2$ …7

To show the effect of nitrogen oxides (NO_x, NO and NO_2) on ozone concentration a proportion NO/NO_2 is calculated. Figure (5) indicates that the increasing in NO/NO_2 ratio is accompanied by decreasing in ozone concentration, this indicated in WHO report (WHO, 2003 – 2004) and accepted with many researches (Masoudi *et. al*., 2015).

Troposphere ozone is formed by the reaction between volatile hydrocarbons, CO and NO under sunlight, so this paper study the correlation between ozone and nitrogen oxide forms. Peak Sunlight is in the summer months, to ensure the maximum photochemical activity and the best time for NO reaction during the day, the hourly ozone, NO_x and NO concentrations are taken for the period (8.00A.M. – 2.00 P.M.). Figure (6) shows the relationship between hourly ozone concentration and (NO_x-NO)/NO_x ratio. It is measuring the degree of NO reaction. Ozone increases with increasing in (NO_x-NO)/NO_x ratio as indicated by many researchers (Rasheed *et. al.*, 2014).

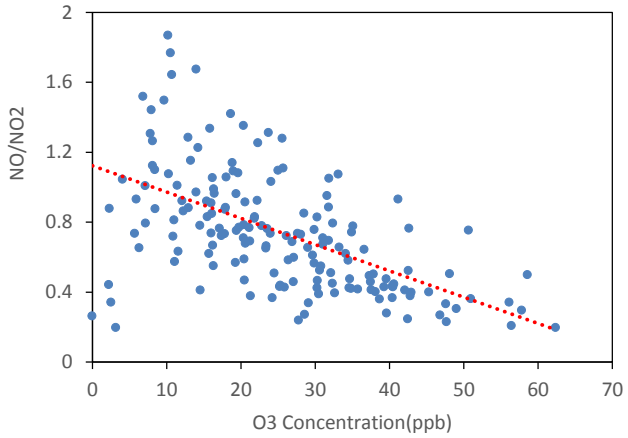

Figure (5): Relationship between daily ozone concentration and NO/NO_2 ratio.

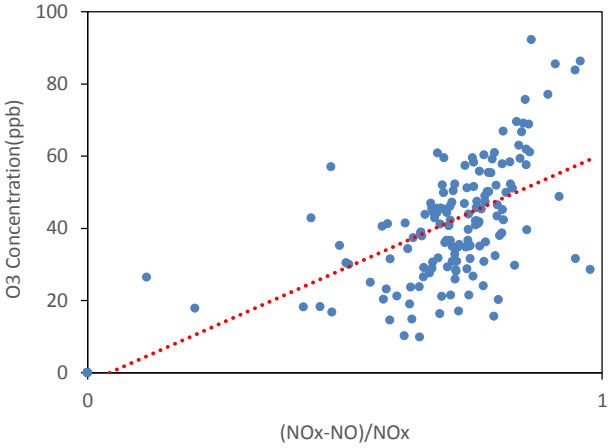

Figure (6): Relationship between hourly ozone concentration and (NO_x-NO)/NO_x ratio for the period (8.00A.M. – 2.00 P.M.).

4. Conclusions

In this paper, the relation between ozone and other air pollutants is studied in Al-Hilla city for the period 2015-2016. According to the results, there is no significant correlation between ozone and SO_2, CO_2 ($\rho > 0.05$). High level of significance is between ozone and the forms of nitrogen oxides ($\rho < 0.01$), this relationship is more complex and affected by more factors such as the presence of solar radiation during the day, air pollutants reactions and volatile organic compounds (VOCs) concentrations in the ambient air. Many ratios used to express this relation such as NO/NO_2 and $(NO_x\text{-}NO)/NO_x$. Ozone concentration decreases with increasing of NO/NO_2 and vice versa for $(NO_x\text{-}NO)/NO_x$. The maximum ozone concentration is in the summer months June, July and August 39.30 ppb, 45.05 ppb and 36.63 ppb respectively and vice versa in the winter months, also the peak hourly concentration value is in the afternoon because of high temperature also high solar intensity. Ozone concentration also affected by traffic load which increases the concentrations of volatile organic compounds. Ground level ozone have revers effect on human health and cause different respiratory, lung and heart diseases, so we need to meet the ambient air quality standards and putting suitable strategies for minimizing air pollutants concentrations especially in Iraq because of the long period of the summer months and the higher temperature degrees in these months.

5. References

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