MEASUREMENT OF GROUND LEVEL OZONE IN SELECTIVE LOCATIONS IN BAGHDAD CITY

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ABSTRACT

The ground level ozone concentration at different locations in Baghdad city was identified. Five different sites have been chosen to identify the ground level ozone concentration. Al- Dora and Al-Za'afarania were chosen as areas contained point source (power plant station) in addition to high traffic load , while Al –Uma park, Aden square and Al-Mawal square were chosen as area contained heavy traffic only (line source). The measurement focuses on spring and fall because these periods display favorable meteorology to ozone formation. During the research period the maximum values (peaks) for ground level ozone concentration were observed at fall: at Al-Za'afarania area 101ppb as an average, at Al-Dora 87 ppb as an average and at line source areas 48 ppb as an average. Among the line sources area Al-Mawal square represent the highest peak value at fall 68 ppb. At spring the peaks of ozone concentration observed to be at the same height, 50 ppb for all sites. The downwind sites from the power plant stations at Al-Dora and Al-Za'afarania areas record higher ozone peaks compared with up wind sites. It can be concluded that the effect of power plant stations in forming ozone is larger than traffic load.

The comparison between the ground level ozone concentrations that measured during the research period in spring and fall, and the ambient air quality standards (AAQS) shows that:

- No exceeded levels were observed in spring for all sites.
- In fall the AAQS for ozone was exceeded in Al-Za'afarania area at 12: PM, 1: PM, 2: PM and 3: PM, and in Al-Dora at 2: PM.

الخلاصة

يهدف البحث الى تعيين تراكيز غاز الاوزون عند المستوى الارضي لعدة مناطق في مدينة بغداد . تم اختيارخمسة مناطق وهي منطقة الدورة و منطقة الزعفرانية والتي تمثل مصدر للتلوث النقطي (بسبب وجود محطات توليد الطاقة الكهربائية) اضافة الى انها مناطق مزدحمة بالمركبات. وتم اختيار حديقة الامة وساحة عدن وساحة الموال كمناطق مزدحمة بالمركبات
(مناطق ذات مصدرخطي للتلوث). القياسات تمت في فصل الربيع والخريف لان هذي الفترة تمثل افضل فترة لتكون الاوزون. خلال فترة البحث تبين ان اعلى قيمة لتركيز الاوزون ظهرت خلال فصل الخريف: في منطقة الزعفرانية ١٠١ جزءاً بالبليون كمعدل ، في منطقة الدورة ٨٧ جزءا بالبليون كمعدل ، وفي مناطق التلوث الخطي ٤٨ جزءا بالبليون كمعدل. ساحة الموال سجلت اعلى قيمة لتراكيز الاوزون لمناطق التلوث الخطي في الخريف والبالغة ٦٨ جزءا بالبليون .اما في الربيع اعلى تركيز للاوزون كان متساوياً تقريبا لكافة المناطق ,٥٠ جزءاً بالبليون . في منطقة الدورة والزعفرانية خلال فصل الخريف، القياسات التي تمت في المناطق التي هي باتجاه الريح السائدة اظهرت قيم اعلى من القياسات التي تمت بعكس اتجاه الرياح السائدة . هذا يعطي مؤشر الى ان تأثير محطات توليد الطاقة الكهربائية على تكون الاوزون اكبر من تأثير حمل المركبات. ان المقارنة بين تراكيز الاوزون عند المستوى الارضي خلال فترة البحث مع المحددات القياسية للهواء المحيط بينت انه لا يوجد تجاوز في فصل الربيع ، كما بينت انه تم تجاوز المحددات في منطقة الزعفرانية في الساعة الثانية عشر،الواحدة ،الثانية والثالثة بعدالظهر خلال فصل الخريف. وكذلك تم تجاوز المحددات في منطقة الدورة في الساعة الثانية بعد الظهر.

KEY WORDS : Ozone; Photochemical smog; Air pollutant; secondary air pollutant.

1. INTRODUCTION

Tropospheric ozone is an important secondary air pollutant in the atmosphere that has received extensive attention in the literature (Abdul-Wahab, et al., 2005; Al-Alawi et al., 2008; Al-Khalaf, 2006; Bader, et al., 2008).It has been reported that ozone is a major oxidant, and it is the most important index substance of photochemical smog which has been recognized as one of the key pollutants degrading the air quality (Arya, 2002). There are no significant primary emissions of ozone into the atmosphere and all the ozone found has been formed by chemical reactions that occur in the air. Ozone produced when the primary pollutants, nitrogen oxides (NO_x) and the volatile organic compounds VOCs (often called non-methane hydrocarbons (NMHC), which are referred as ozone precursors, interact under the action of sunlight. Meteorological parameters (temperature, wind speed and direction, solar radiation, humidity, boundary layer depth) highly influence the formation and dispersion of ozone. Radiation, temperature and humidity drive the chemical reactions producing ozone, while boundary layer characteristics and the absence of wind are the factors which respectively lead to the build-up of precursors and limit their dispersion. The concentration varying widely from region to region, with the time of year, and the time of the day.(Lengyel, 2004; San Jose´ et al., 2005; Al-Alawi et al., 2008).

Both NO_x and VOCs are emitted from a large pool of sources. These sources are typically classified into four categories: area, point, mobile, and biogenic. Emissions of NO_x are produced primarily by motor vehicle engines, power plants, industrial plants, boilers and burning of fossil fuels. VOCs emissions are motor vehicle emissions, gasoline vapors, and chemical solvents. Biogenic volatile organic compounds(BVOCs) which almost emitted from forest and marshland like terpenes and isoprene are also contribute to ozone formation (Pfister et al.,2008). High concentration of ozone and other photochemical oxidants are observed over most large cities and metropolitan areas during warm months. Considerable levels of ozone are also found to exist over large rural regions in which ozone gets transported from large urban and industrial areas. Thus, tropospheric ozone is not merely an urban air pollution problem, but also a regional problem (Arya, 2002).

The impact of biogenic emissions on surface O has been examined by many studies, biogenic volatile organic compounds is a source of hydroperoxy and organic peroxy radicals, which can react with NO_x to stimulate O production and react with peroxy acetyl nitrate (PAN) which influence the global distribution of nitrogen oxides (NO_x) and thus indirectly impact O production (Pfister et al., 2008).

Unlike the “bad” tropospheric ozone there is also the “good” stratospheric ozone. Most of the stratospheric ozone resides with its maximum concentration around 20km above the surface of the earth (Jacobson, 2002).

Stratospheric ozone plays a beneficial role by absorbing ultra violet radiation from the sun. So it protects the life on earth from the destructive effects of such radiation. The large amounts of ozone produced in the stratosphere are inhibited from entering the troposphere by a sharp increase in atmospheric stability at the tropopause. Specific meteorological conditions may cause the descent of ozone rich air of stratospheric origin to the lower troposphere. The background ozone concentration is not easily measured. However, it has been estimated that the average ozone concentration on the earth’s surface caused

by such natural processes is between 20 and 50 ppb depending on the geographical location and latitude (Derwent et al., 1978).
Ozone is well known as strong oxidant. It has direct effect on human, vegetation and materials. Inhalation of air mass containing 1 ppm by volume ozone causes severe irritation and headache. Ozone irritates eyes, upper respiratory system, and lungs. Inhalation of ozone can sometimes cause fatal pulmonary edema which is an abnormal accumulation of fluid in lung tissue. Ozone generates free radicals in tissue. These reactive species can cause lipid peroxidation, oxidation of sulfhydryl (–SH) groups, and other destructive oxidation processes (Manahan, 2000; Schlink et al., 2006; Palli et al., 2008).
Phytotoxicity of ozone is characterizing the yellow and black spots on a green leaf. Wang et al., (2007) show that ozone effects on corn and soybeans in both quality and productivity in Linan, China. Quijano et al., (2009), show that phytotoxicity increased with altitude, substantial ozone injury symptoms were found at all altitudes on tobacco plants exposed to the ambient air, although, damage was more intense in the plants at greatest altitudes. Ground level ozone may cause reduced resistance to fungi, bacteria, viruses and insect (OTA, 1989). These impacts on sensitive species may result in declines in agricultural crop. Ramo et al., (2006), verify that ozone (40-50 ppb) reduced the total community biomass production and the growth of three species out of seven.
Ozone has direct effect on materials by reduction for its virtual life. Ozone attacks synthetic rubbers causing deterioration of rubber by cracking. The mechanism appears to be an attack at the double bonds in the hydrocarbon polymer used in the rubber (Boubel, 1994). Some of rubber manufacturers make test to their product by the exposure to high ozone concentration they call it ageing rubber tests. Ozone also attacks the cellulose in textiles, reducing the strength of such items and changing white color of fabric to the yellow (Brown, 2001).
Because ozone has those harsh effects on both life and material, the United States Environmental Protection Agency (USEPA) considered ozone as criteria pollutant. USEPA ozone standards have been change according to the development of research on life requirement. To attain the ozone standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentration measured at each monitor within an area over each year must not exceed 0.075 ppm (Bailar, 2008).
The aim of this research is to identify the ground level ozone concentration in Baghdad city at different locations. Five locations are chosen, Al- Dora and Al-Za'afarania sites are chosen to show the effect of the thermal power plant (as point source), and AL-Uma Park, Aden square and AL-Mawal Square are chosen to represent line source

2. FIELD WORK

2.1 Site Description

Five different sites have been chosen to evaluate ground level ozone in Baghdad city. Figure (1) and Table (1) show the description of these five sites. Different measuring points at Al Dora and Al-Za'afarania sites were chosen to show the effect of the power plant (as point source) while Aden square in Al-Kadhemia area , Al-Mawal square in Al-Mustansiriya area and Al-Uma park in Bab Al-Sharqi area were chosen to represent line sources.

2.2 Data collection

Ozone monitor (S-500) from Aeroqual New Zealand Company used to measure ozone concentration in (ppb), the sensor

head for ozone monitor is working on Gas Sensitive Semiconductor (GSS) principle,
The geographical positioning system (GPS) is of Taiwan production with Garmin trade mark model "etrex, Vista" it has been used to define the location in term of longitude and latitude with accuracy limit of about 5 meters. The ozone meter was fixed on aluminum bare at 1.6 m height to simulate respiratory system intakes. Care must be taken that no high buildings or trees were present near the measuring site. Values of day-light time period were used i.e. from 8: AM to 4: PM (LST) local standard time, since this documented as the most important photochemical production period. The measurement focus on spring and fall, these periods display favorable meteorology to ozone formation in Baghdad city, as indicated by Kanbour et al., (1987) and AL-Quzweny,(1990). Other researchers also indicate that these periods display favorable meteorology to ozone formation as in central Makkah ,Saudi Arabia (Al-khalaf, 2006) and in Rabia Area, Kuwait city (Bader et al.,2008).

3. RESULTS AND DISCUSSIONS

3.1 Al-Dora Area

Al-Dora area was considered as a case study, the area was expected to be affected by the pollutants which are emitted continuously from Al-Dora Power Plant and the traffic load at that area. Al-Dora Power Plant located in the south west of Baghdad city and to the west of the Al-Dora Refinery and the South Baghdad Power Plant Fig. (1). The wind rose over a period of one full year (2008) is constructed Fig. (2), using wrplot V.5.9 program. The wind rose shows that the majority of the prevailing wind is from the west, therefore the measurement points were selected at different locations (D1, D2, D3, D4, D5, D6, and D7) down wind and upwind from Al-Dora Power Plant, Fig. (3).

Figure,(4- a, b and c) shows the diurnal variation of ozone concentration at spring, early summer and fall downwind from Al-Dora Power Plant , while Fig. (4-d) shows the diurnal variation of ozone concentration upwind from Al- Dora Power Plant. Figure (4-e) represents the comparison between spring, early summer and fall.
From Fig. (4) it can be notice that:

- Almost two peaks were appeared in measuring sites with different heights.
- The same trend for ozone variation was observed at spring Fig. (4-a). The measurement was done at site D1, which was downwind from Al-Dora Power Plant, with south east wind direction at that date. The first peak (65 ppb average) was observed at 11:00 AM while the second (55 ppb) at 1:00 PM.
- In early summer Fig. (4-b), the measurements were done at three different locations downwind from Al-Dora power plant (D3, D4 and D5). At D4 two peaks were observed, the first 46.5 ppb at 11:00 AM and the second 57 ppb at 1:00 PM. At D3 and D5 one peak was observed, 40 ppb at 12:00 PM and 45 ppb at 1:00 PM respectively.
- In falls Fig. (4-c), measurement was done at two different locations D2 and D7 downwind from AL-Dora power plant. The highest peak of ozone concentration 236 ppb during the research period was observed at this area at point D7 at 2:PM .
- Multi lower peaks were observed up wind from Al-Dora power plant, Fig. (4-d) compared with downwind locations. The most probable source is the prevalent traffic load near by

the road. The measurement applied at two locations D2 and D6. At location D2 the highest peak 37 ppb was recorded at October. It may be realized that the effect of Al-Dora Power Plant as point source in forming ozone is larger than the traffic load.

- It can be noticed that from Fig. (4-e) , fall represent a higher ozone peak 87 ppb compared with early summer 47 ppb and spring 50 ppb.

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3.2 Al-Za'afarania Area

The measurements were located at four points (Z1, Z2, Z3 and Z4) Fig. (5), downwind and upwind from the south Baghdad Power Plant. Figure (6-a,b) represent the diurnal variation of ozone concentration at spring and fall while Fig. (6-c) illustrate the comparison between them.

From Fig. (6), it can be observed that:

- Two peaks were appeared in all locations. The peaks are nearly at same height in spring as well as in fall,
- In spring the measurements were applied at two locations Z1 and Z2 downwind from south Baghdad Power Plant. The first peak (50 ppb average) was appeared at 11:00 AM and the second (55 ppb average) appears at 1:00 PM, Fig. (6-a).

- In fall the measurements were applied at two locations, Z3 upwind and Z4 downwind from the south Baghdad Power Plant. The same trend was observed for the two locations Fig.(6-b), but a higher peaks can be noticed for location Z4 downwind the station. Downwind peaks 137 and 153 ppb appeared at 12: PM and 3: PM respectively, while up wind peaks 50 and 48 ppb appeared at 11: AM and 3: PM respectively.
- In spring there is a decline in ozone concentration at 12: PM while at fall the decline at 1: PM. No heavy traffic was observed at that time.
- It can be noticed that from Fig. (6-c), fall represent a higher average peaks (90 and 101ppb) compared with spring (50 and 55 ppb), also a shift in peak time can be noticed at fall. Kanbour et al.(1989) during their research period observed that the maximum value of ozone concentration, 285 ppb was recorded at Al- Za'afarania site in Baghdad city in October (1987).

3.3 Line sources

The measurements were located at three sites, Al-Uma Park, Aden Square and Al-Mawal Square, Fig. (7). Figure (8 -a, b, c, e, f, and g) shows the diurnal variation of ozone concentration during spring and fall for the three sites, while Fig. (8 -d, h) illustrates the comparison between these sites during spring and fall. From this figure it can be noticed that:

- Almost two peaks were appeared in all sites and in some times three peaks will appear.
- In spring a same trend for ozone concentration was observed in AL- Uma park, Aden square and Al–Mawal square. The highest peaks (45-58 ppb) were noticed after 12: PM for all sites.
- In fall many peaks were appears clearly. For Al-Uma park and Aden Square, the first peak (52 and 55 ppb average) noticed respectively at 11: AM and the second peak (44 and 50 ppb average) at 2: PM. For Al-Mawal square the first peak and the second peak appears earlier. The first 38 ppb at 10: AM and the second 68 ppb at 1: PM.
- A third peak occur at Aden square and Al-Mawal square after 4: PM, this was because these areas are commercial areas.
- The highest ozone peak at the present research period (84 ppb) in line source areas was recorded in Aden square at 1: PM.
- No clear difference in the peaks of ozone concentration between spring and fall were observed in these three areas, only clear peaks were appeared in fall, Fig. (6- d,h) .

4. COMPARISON BETWEEN POINT SOURCE,LINE SOURCE AND AMBIANT AIR QUALITY STANDARDS

It can be noticed from the previous results that line source areas had lower peaks for ground level ozone concentration compared with areas contained point source (as an average) at fall 87 ppb for Al-Dora, 101 ppb for Al- Za’afarania and 48 ppb for line source areas . While in spring the peaks were observed to be nearly equal 50 ppb in Al-Dora, 51 ppb at Al- Za’afarania and 51 ppb at line source areas,

The comparison between ground level ozone concentration for the period of the present research during spring and fall and the ambient air quality standards (AAQS) identify that:

- No exceeded levels were observed in spring for all sites Fig. (9-a).
- In fall the AAQS for ozone was exceeded in Al-Za'afarania area at 12: PM, 1: PM, 2: PM and 3: PM, and in Al-Dora at 2: PM Fig.(9-b).

5. CONCLUSIONS

The following conclusions can be considered from the present research:

1-Almost two peaks were appeared in all sites, a third peak was observed at afternoon in commercial areas (Aden square and Al-Mawal).

2-In all sites the peaks of ozone concentration appeared clearly in fall compared with spring. 3-The highest ground level ozone concentration was found during fall in all sites. 4 The highest peak of ground level ozone concentration was found during fall in Al-Za'afarania area (as an average) 101 ppb at 3: PM.

5- No clear variation in ozone concentration peaks between spring and fall in line source areas. 6- Area contained point source represent higher ozone peaks compared with areas contained line source only in fall, while in spring the peaks were observed to be approximately equal.

7- Upwind areas from Al-Dora Power Plant contained lower ozone concentration compared with downwind areas.

9-The AAQS for ozone concentration was exceeded in Al-Za'afarania areas at 12: PM, 1: PM, 2: PM and 3: PM and in Al-Dora at 2: PM in fall at the present research period.

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Table (1): Measuring sites descriptions

Site	Name and Location of Measuring Site	Code	Coordinate		Ozone source
1	Aden Square (North waste of Baghdad city)	A	N 33 21.764	E 44 20.007	Heavy traffic
2	Al Mawal Square (North east of Baghdad city)	M	N 33 22.194	E 44 24.201	Heavy traffic
3	Al Uma park (In the center of Baghdad city)	U	N 33 19.747	E 44 24.628	Heavy traffic
4	Al Za'afarania (South east of Baghdad city, located near South Baghdad power plant and to the north east of Al-Dora refinery)	Z1	N 33 17.692	E 44 27.265	South Baghdad power plant and heavy traffic
		Z2	N 33 17.127	E 44 27.785	
		Z3	N 33 17.294	E 44 26.893	
		Z4	N 33 17.061	E 44 27.314	
5	Al- Dora (South of Baghdad city near the Al-Dora power plant)	D1	N 3315 50.67	E 44 2144.7	Al-Dora power plant and heavy traffic
		D2	N 33 16.077	E 44 21.87	
		D3	N 3315 22.99	E 44 2156.13	
		D4	N 331530.31	E 44 2234.66	
		D5	N 33 15.348	E 44 22.698	
		D6	N 33 15.315	E 44 22.978	
		D7	N 33 15.281	E 44 22.524	

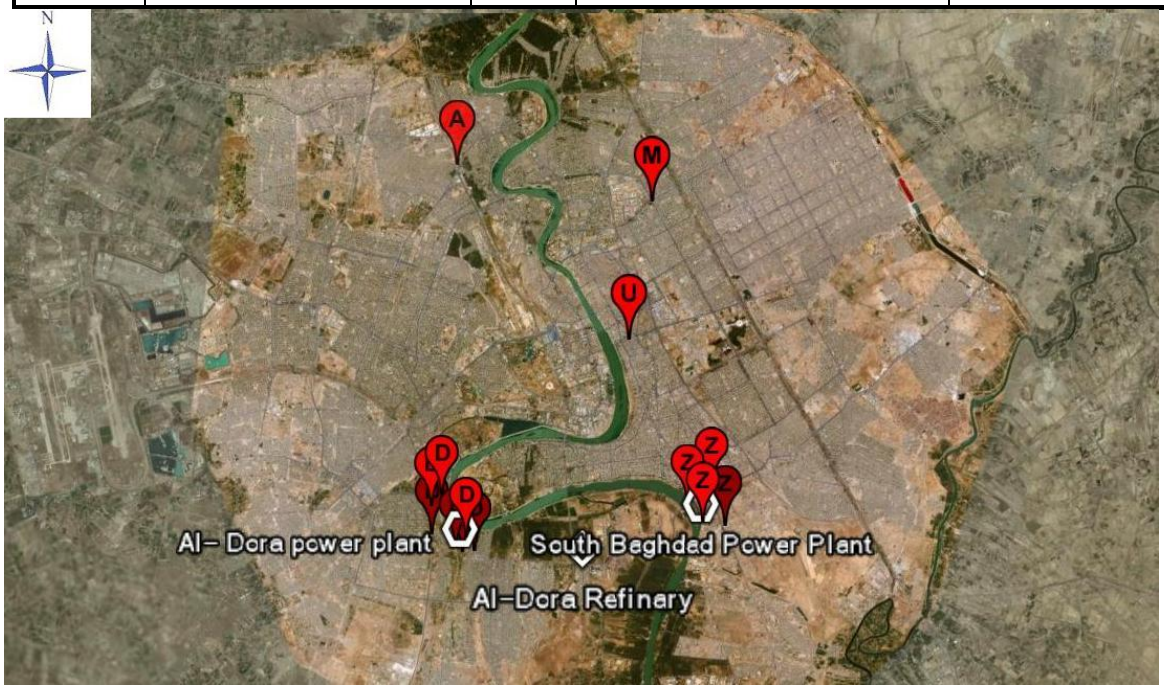


Fig.(1):Aerial photo for Baghdad city shows the measuring sites.

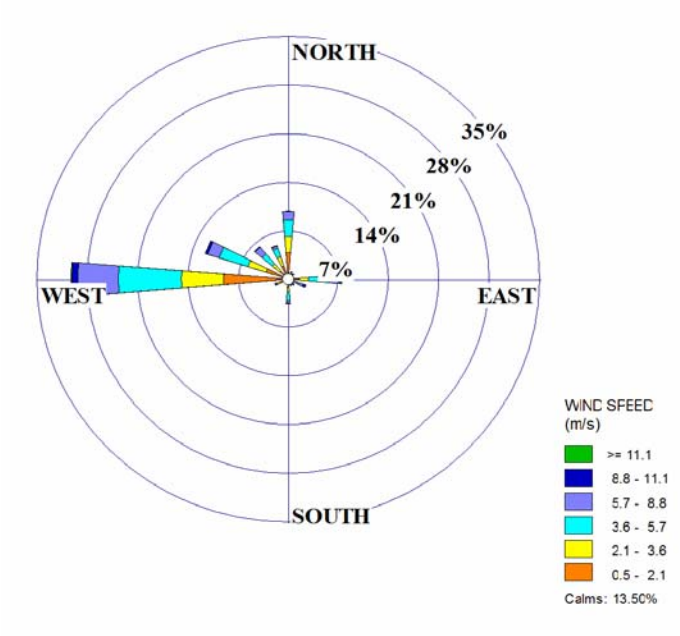


Fig.(2): Wind rose for Baghdad city one full year(2008).

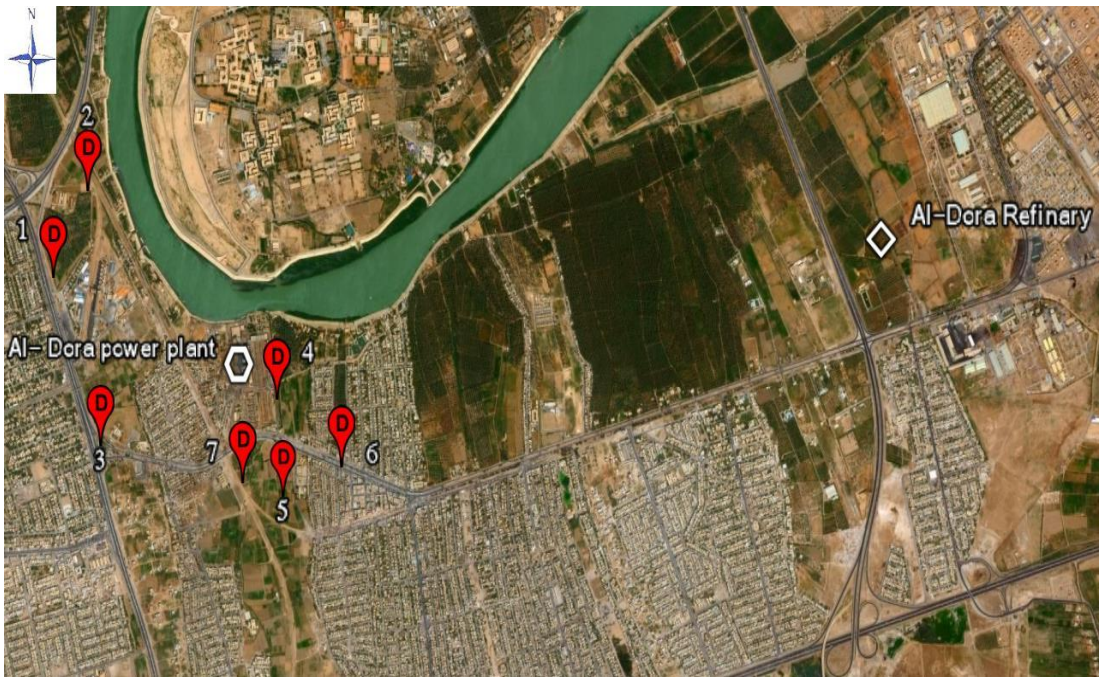
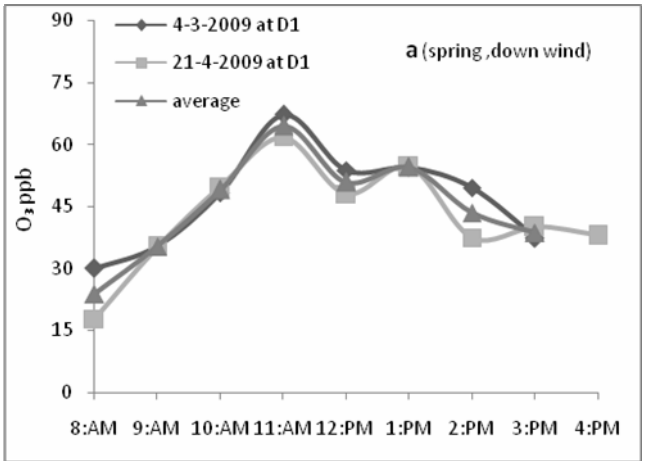
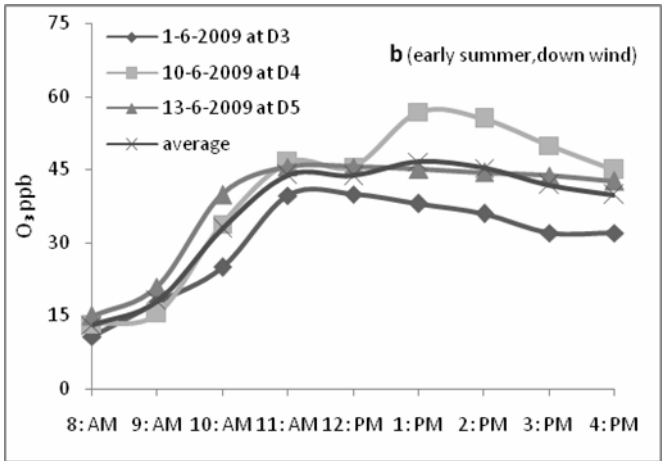
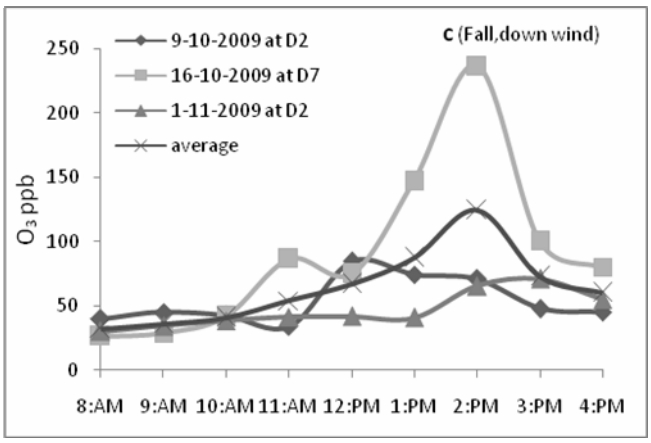
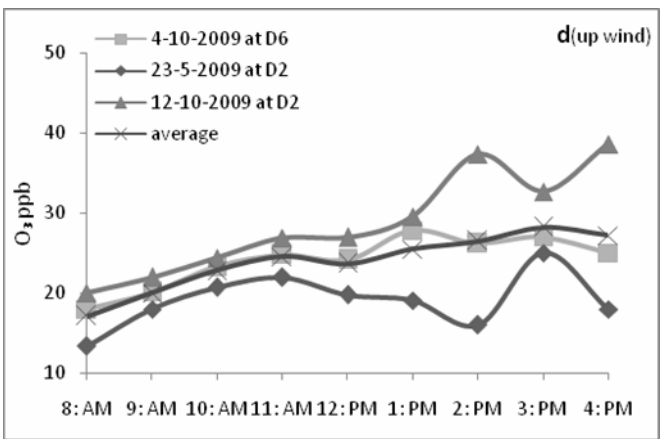


Fig.(3): Aerial photo for Al-Dora area shows the measuring sites around the power plant.









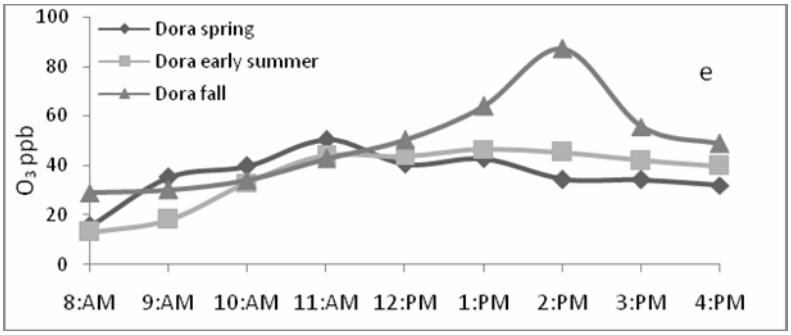
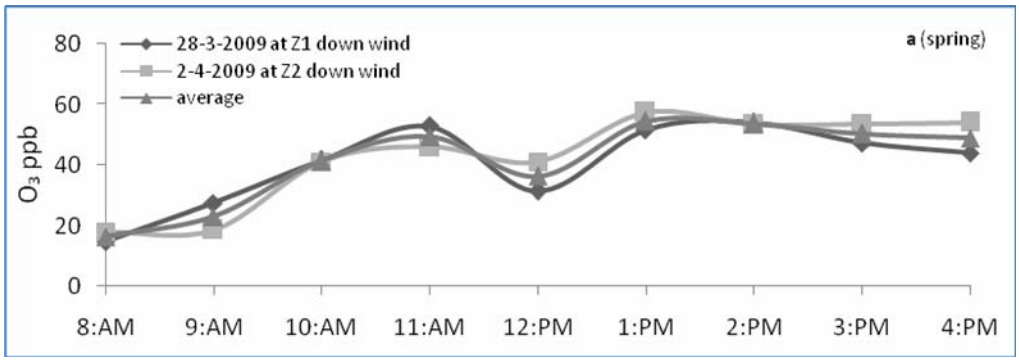
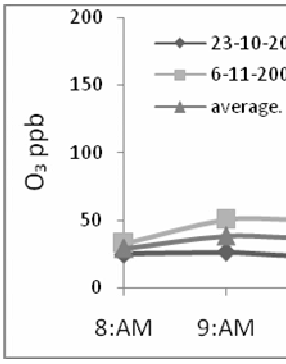


Fig. (4): Diurnal variation in ground level ozone concentration for Al-Dora site (a)at spring (b) at early summer (c) at fall (d) up wind (e) comparison between spring, early summer and fall (upwind and downwind measurements).

Fig.(5): Aerial photo for Al-Za'afarania area shows the measuring sits around the power plant.


a (spring)
28-3-2009 at Z1 down wind
2-4-2009 at Z2 down wind
average
O3 ppb
80
60
40
20
0
8:AM
9:AM
10:AM
11:AM
12:PM
1:PM
2:PM
3:PM
4:PM


200
150
100
50
0
O3 ppb
8:AM
9:AM
average.

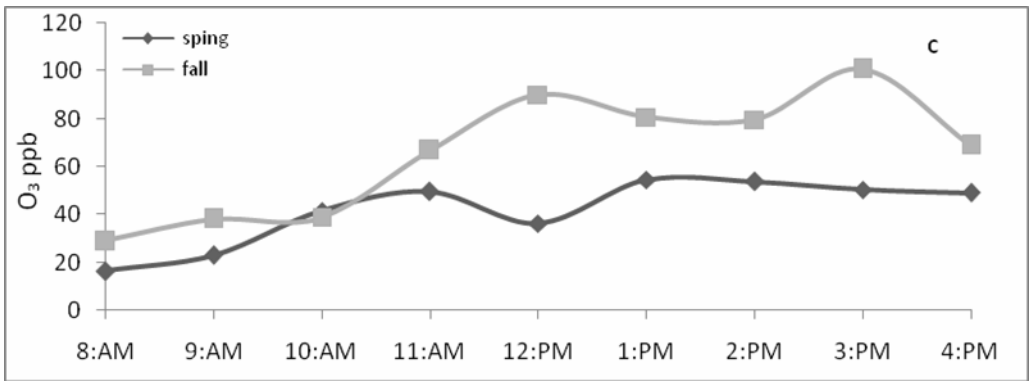
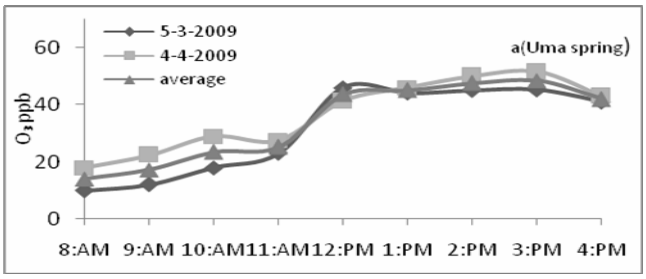
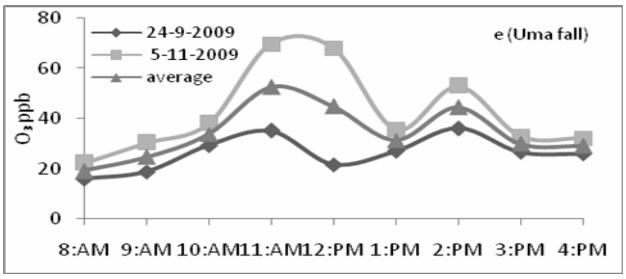
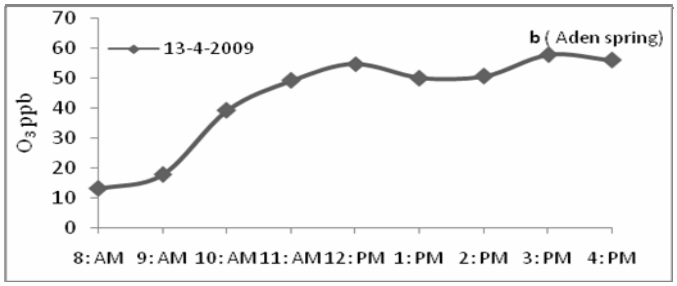

c
sping
fall
O3 ppb
120
100
80
60
40
20
0
8:AM
9:AM
10:AM
11:AM
12:PM
1:PM
2:PM
3:PM
4:PM

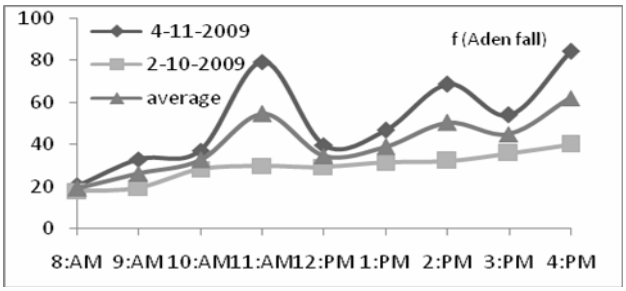
Fig. (6): Diurnal variation in ground level ozone concentration for Al-Za'afarania site (a) at spring (b) at fall (c) comparison between spring and fall.

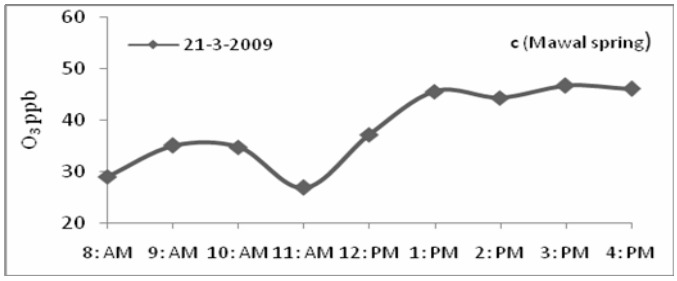
Fig. (7): Aerial photos for line Source Area (U) Uma park (A) Aden square and (M) Al-Mawal Square.

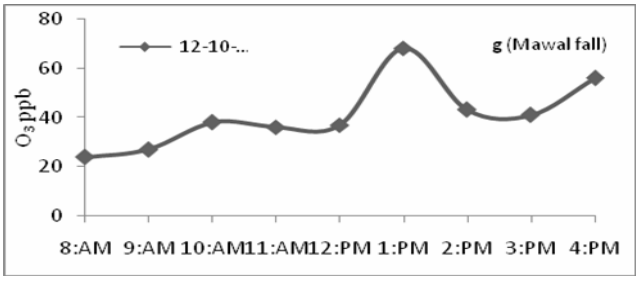












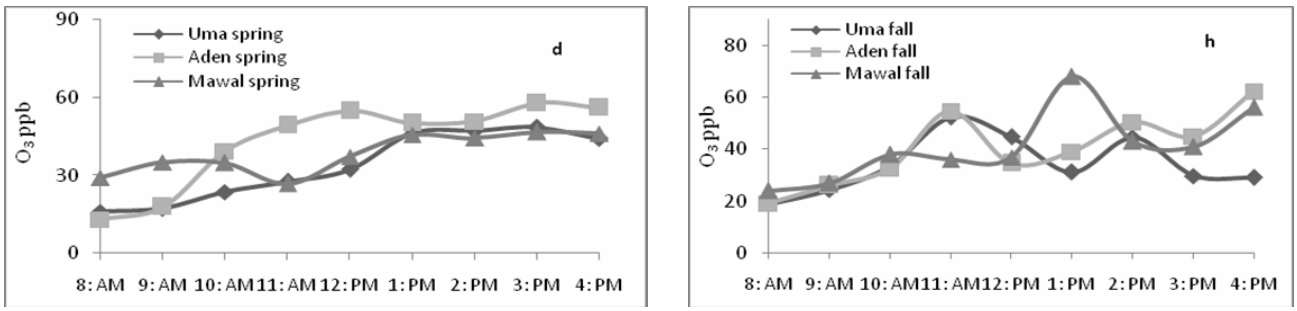
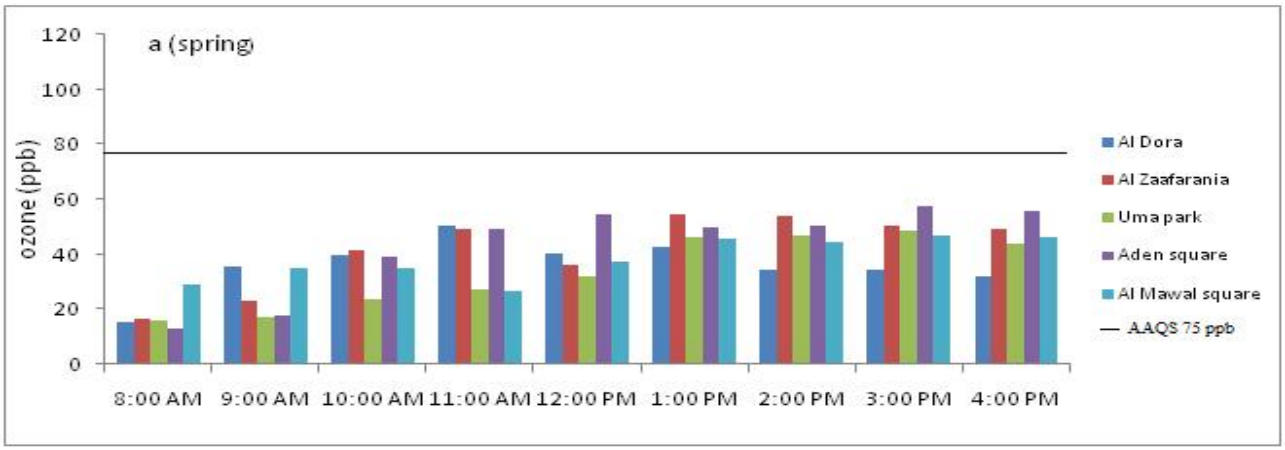


Fig.(8): Diurnal variation in ground level ozone concentration for line source sites (a) in Uma park at spring (b) in Aden square at spring (c) in Al-Mawal square at spring (d) comparison between ine source sites in spring (e)in Uma park at fall (f)in Aden square at fall (g)in Al-Mawal square at fall (h)comparison between line source sites in fall



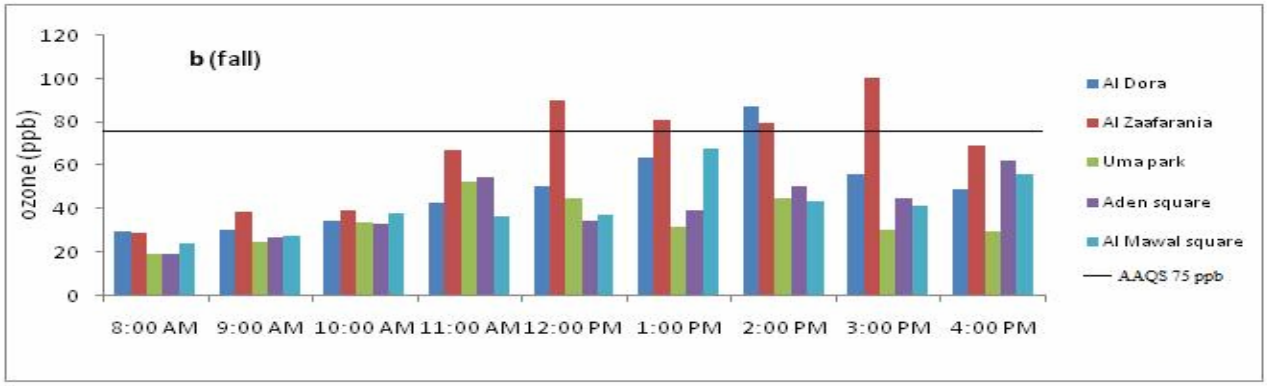


Fig.(9): Compression between measured value and AAQS