The Hashemite Kingdom of Jordan

Ministry of Environment

Ambient Air Quality Monitoring Report

In (Amman-Irbid-Zarqa)

2019

Ministry of Environment

National Ambient Air Quality Monitoring Network

Amman - Irbid - Zarqa

Yearly Report

2019

Abstract

The Ministry of Environment monitors ambient air quality as obligated by Environmental Protection Law No. 6 of 2017 and the Air Protection bylaw No. 28 of 2005, which include the obligation to monitor air pollution in the interest of public health.

Criteria air quality pollutants (PM, NO2, SO2, CO, Ozone) are continuously measured on an hourly basis and measurements are evaluated against limits set in Jordanian Standard No. 1140/2006 for ambient air quality. Exceedances as stipulated in the standard are reported.

Measurement of ambient air quality over several years within the various AQ stations and various regions in Jordan provides necessary data needed to formulate recommendations to decision makers in order to develop mitigation strategies to improve air quality in each region. Improved air quality helps to promote better health for Jordanian citizens thus contributing to the achievement of the sustainable development goals. In addition, continuous measurement is necessary to activate emergency control procedures to prevent or reduce air pollution accidents.

In order to achieve the monitoring goals, a national ambient air quality monitoring network was established in 2014 consisting of 12 ambient air quality monitoring stations. Locations of the monitoring stations were chosen based on a scientific study, and cover industrial ,traffic and residential areas within Amman, Irbid and Zarqa, distributed as follows:

- 7 stations located in Amman (GAM, KAC, KHG, MAH, TAB, UNI, and YAR).
- 3 stations in Zarqa (HAJ, MAS, and ABK/HH).
- 2 stations in Irbid (HSC, and BAR).

The stations monitor the following pollutants:

- Particulate matter with aerodynamic diameter ≤ 10 microns (PM10)
- Carbon monoxide (CO)

- Sulfur dioxide (SO_2)
- Nitrogen dioxide (NO_2)
- Ozone (O_3)

Monitoring is carried out continuously and around the clock, and the results are transmitted electronically to a central server where they are stored, audited, analyzed and reports issued on a daily, monthly and yearly basis. The monitoring results are analyzed continuously, and the results are compared with the limits stipulated in Jordanian Standard No. 1140/2006.

This report represents the annual results of air pollutants that were measured through the ambient air quality monitoring stations distributed in Amman, Zarqa, and Irbid cities during 2019. In addition, a comparison to previous results during the period 2015 to 2019 is included. The excedances were determined by comparing the observational results with the limits set out in the Jordanian Standard No. 1140/2006.

The results of the monitoring of ambient air quality for the year 2019 in different locations showed that the air quality was good and within the limits allowed in Jordanian Standard No. 1140/2006, except for particulate matter with aerodynamic diameter ≤ 10 microns **(PM10)**, Where a number of daily average exceedances were observed when compared to the daily average limit specified in the Jordanian standard of 120 microgram/m^3. In addition one station (Mahatta area station) exceeded the annual average limit stipulated in the Jordanian standard of 70 microgram/m^3. The causes of excedances in Particulate Matters are mainly due to sandstorms, traffic and industrial activities.

Exceedances were observed in the hourly averages of Nitrogen dioxide **(NO_2)** as compared to the limit specified in the Jordanian standard, which is 210 ppb in only two stations (Mahatta area in Amman and King Abdulla Sports city area in Irbid). Also, daily averages exceeded the limit stipulated in the Jordanian standard of 80 ppb in Mahatta area and Tabarbour stations in Amman.

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INTRODUCTION

1.1 Monitoring Sites

The Ministry's Ambient Air Quality Network consists of 12 fixed monitoring stations distributed between Amman, Irbid and Zarqa, where Table (1.1) shows the stations name and type and figure (1.1) shows the exact location of each monitoring station.

The locations of the monitoring stations were chosen after reviewing the gas concentrations through test tubes distributed in the three cities. The concentrations of particles in these areas were also monitored by special devices approved for this purpose, and results were analyzed and mapped showing the areas where gases and particles were in higher concentrations. Thus, the monitoring stations were permanently placed in those areas, and the sites were chosen in a manner that covers the different activities in the industrial areas, commercial areas, areas with traffic densities and residential areas.

Table (1.1): Names and locations of ambient air quality monitoring stations in Jordan.

Short Name	Name in Arabic	Type of Station	Name in English
Amman			
KHG	حدائق الملك حسين	Background	King Hussein Gardens
GAM	أمانة عمان الكبرى	Urban	Greater Amman Municipality
TAB	مجمع الشمال/ طبربور	Traffic	Tabarbour
MAH	ماركا / المحطة	Urban	Marka – Mahata
UNI	شارع الجامعة / صويلح	Traffic	University street Sweile
KAC	مدينة الملك عبدالله الثاني الصناعة / سحاب	Industrial	King Abdullah II Industrial City / Sahab
YAR	اليرموك	Industrial	Yarmuk
Irbid			
HAJ	مركز صحي وادي الحجر	Traffic	Health Center Wadi Hajjar
MAS	المسلخ البلدي منطقة المصانع	Industrial	Main slaughter house Masane' Zone
ABK/HH	القاعة الهاشمية	Urban	Hashemite Hall
Zarqa'a			
HSC	مدينة الحسن الرياضية	Traffic	AL Hassan Sport City
BAR	شارع البارحة	Urban	Al Barha Street

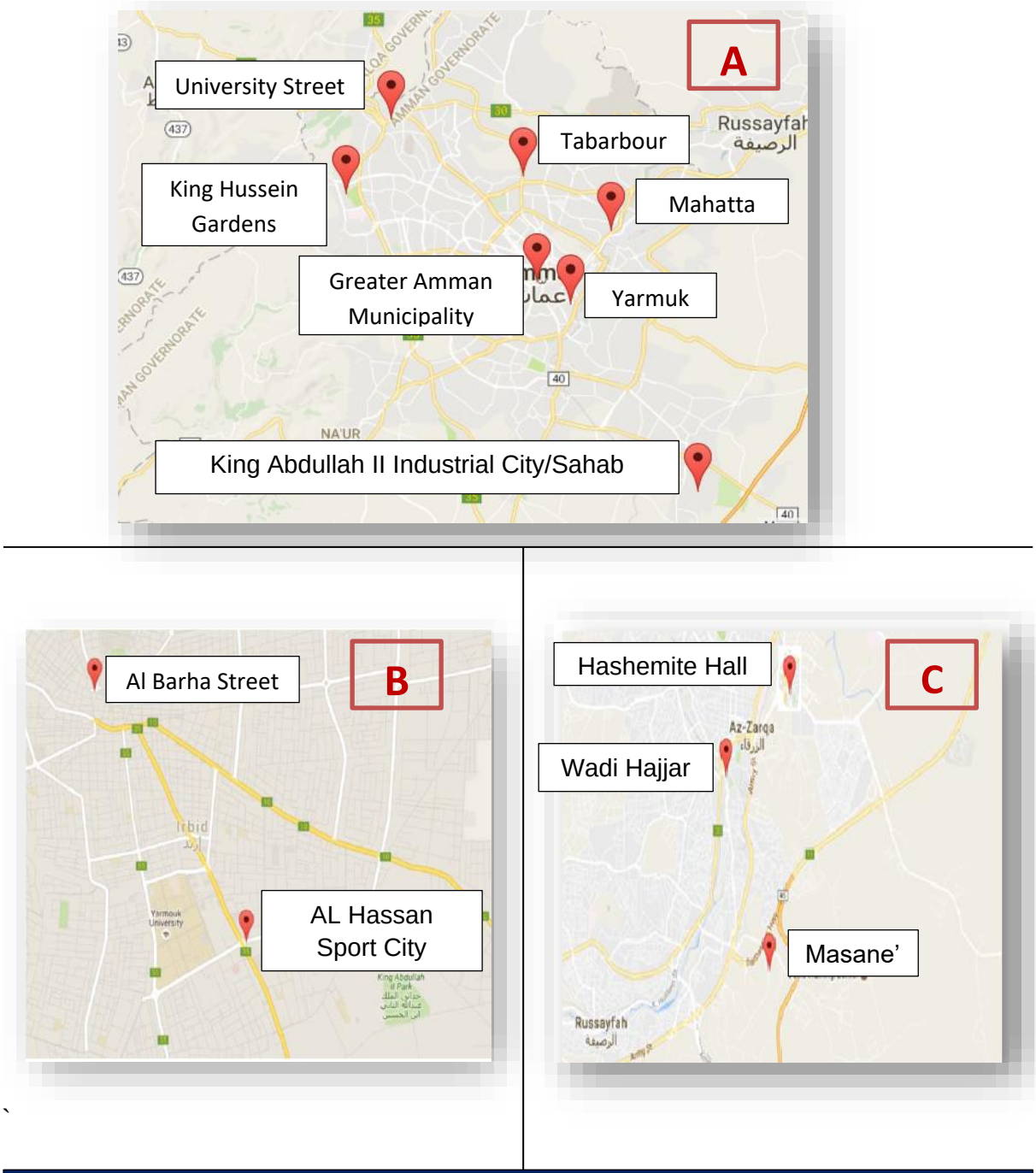

Figure (1.1): A) Distributed Stations in Amman, B) Distributed Stations in Irbid , C) Distributed Stations in Zarqa.

1.2 Jordanian Standard for Ambient Air Quality Monitoring

Table (1.2) shows the allowed limits of gases and particulate matter emissions to the ambient air as specified in the Jordanian Standard No. 1140/2006 for the quality of the ambient air. Additionally, the results of the monitoring were compared with the allowed limits and the number of exceeded events are shown below.

Table (1.2) Jordanian Standard for Ambient Air Quality No. 1140/2006

Pollutant	Sample Duration	Maximum Allowable Limit	Number of Allowable Exceeded Events
Sulfur dioxide (SO_2)	One Hour	0.3 part per million (ppm)	3 times in any 12-month period per year
	24 Hours	0.14 part per million (ppm)	Once per Year
	Yearly	0.04 part per million (ppm)	-
Carbon monoxide (CO)	One Hour	26 part per million (ppm)	3 times in any 12-month period per year
	8 Hours	9 part per million (ppm)	3 times in any 12-month period per year
Nitrogen dioxide (NO_2)	One Hour	0.21 part per million (ppm)	3 times in any 12-month period per year
	24 Hours	0.08 part per million (ppm)	3 times in any 12-month period per year
	Yearly	0.05 part per million (ppm)	-
Ozone (O_3)	One Hour	0.12 part per million (ppm)	-
	8 Hours	0.08 part per million (ppm)	-
Particulate Matter (PM10)	24 Hours	120 Microgram (µg/m3)	3 times in any 12-month period per year
	Yearly	70 Microgram (µg/m3)	-

1.3 Pollutants

The pollutants monitored in all three cities include: Particulate matter with aerodynamic diameter ≤ 10 microns (PM10), Carbon monoxide (CO), Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2) and Ozone (O_3). Table (1.3) shows a visual presentation of the monitored pollutants in each station.

Table (1.3): Pollutants monitored in each station.

Type of station	Station Name	Short name	CO	NO_2	SO_2	O_3	PM10	MET
Amman								
Background	King Hussein Gardens	KHG		1	1	1	1	1
Urban	Greater Amman Municipality	GAM	1	1	1	1	1	
Traffic	Northern Bus Station Tabarbour	TAB	1	1			1	
Urban	Marka / Mahata	MAH		1	1		1	
Traffic	University street /Sweileh	UNI		1			1	
Industrial	King Abdullah II Industrial City / Sahab	KAC		1	1		1	
Industrial	Yarmuk	YAR		1	1		1	
Zarqa'a								
Traffic	Wadi Hajjar Health Center	HAJ	1	1	1		1	1
Industrial	Massane'	MAS		1	1		1	
Urban	Hashemite Hall	ABK/HH		1	1		1	
Irbid								
Traffic	Al Hassan Sport City	HSC	1	1			1	
Urban	Al Barha Street	BAR		1	1	1	1	1

1.4 Measurement Analyzers

All analyzers used to monitor the gases and particulate matter at all stations are reference type measuring devices for measuring ambient air pollutants. Analyzers are approved by the American Environmental Protection Agency **(EPA)**, as well as the European International environmental authorities and other global authorities. They are also in compliance with the Jordanian Standard No. 1140/2006 for the measurement of ambient air pollutants. Table (1.4) shows the model of the devices used and their respective examination certificate.

Table (1.4): The type of devices used to measure concentrations of gases and particulate matter at monitoring stations and the approved examination certificates that belong to them.

Pollutant	Model	Examination certificate	Principle of Operation
Particulate Matter **(PM10)**	Thermo 5014i	U.S. EPA Approved PM-10 (EQPM1102-150	Beta attenuation
Nitrogen dioxide **(NO_2)**	Thermo 42i	U.S. EPA Reference Method: RFNA-1289-074; MCerts Certified: MC070093/00; EN14211: 936/21203248/C Report; NF Certificate: 05/01	Chemiluminescence
Sulfur dioxide **(SO_2)**	Thermo 43i	US EPA Equivalent Method: EQSA-0486-060, MCERTS Certified Sira MC070094/00, EN14212: TÜV 936/21203248/D Report	UV-Fluorescence
Carbon monoxide **(CO)**	Thermo 48i.	US EPA Reference Method: RFCA-0981-054, MCERTS Certified Sira MC070095/00, EN14626: TÜV 936/21203248/A Report	Infrared
Ozone **(O_3)**	Thermo 49i	US EPA Equivalent Method: EQOA-0880-047, MCerts Certified MC070096/00, EN14626: 936/21203248/13 Report, NF Certificate: 05/01	Ultra-Violet Photometry

1.5 Calibration

All gas monitoring devices are periodically calibrated using the Thermo Scientific Dynamic Gas Calibrator model 146i and, the Zero Air generator model 111 and calibration Gas bottles. The calibrator produces precise gas levels of nitric oxide, nitrogen dioxide, carbon monoxide, sulfur dioxide and ozone to calibrate the instruments for span and multipoint calibrations. The zero air generator is used to perform zero calibration.

1.6 Meteorology (measurement of weather elements)

Weather elements (wind speed, wind direction, temperature and relative humidity) are measured using sensors at three monitoring stations distributed between Amman, Irbid and Zarqa. The sensors are set at about 10 meters above the ground using a retractable mast.

1.7 Communication and Telemetry

All measurements are automatically transmitted to the ministry of environment central server through internet connection.

1.8 Operation and site Performance

United Technology Establishment (UniTec), under direction of the Environmental Monitoring and Evaluation Directorate at the Ministry of Environment, manages the operation of the network and performs all required maintenance and supply of spare parts for the instruments as well as the shelters, communication network, central servers and IT software.
Furthermore, UniTec performs routine validation of the data and issues daily, monthly and yearly reports for all pollutants and all stations.
Monitoring stations are operated according to the manufacturer's guidelines and in compliance with international quality assurance standards for monitoring ambient air quality. These guidelines and multiple other measures aim to reduce data loss and ensure data security. To increase the percentage of data collected and ensure accuracy, UniTec has a Maintenance team dedicated to resolving any issues on site, as soon as any warning signal or defect in the monitoring devices arises.

1.9 Information and data on ambient air quality

The Ministry has electronically linked the collected data with a global monitoring network https://aqicn.org and has created a website available to all citizens and researchers https://www.jordanenv.com/, broadcasting the results of the ambient air quality.

Live broadcast of the ambient air quality index

The Ministry of Environment has made great efforts to monitor ambient air quality in Jordan, culminating, since 2018, in the direct data broadcast of the National Network for Ambient Air Quality Monitoring on the Ministry's website in the form of an air quality indicator (Air Quality Index). This is due to the Ministry's duties to participate in national, regional and global monitoring efforts, initiatives and programs. The website continuously shows the air quality index for each of the air quality monitoring stations in the major cities of Amman, Zarqa and Irbid. All concerned parties and citizens can track the ambient air quality index around the clock to take appropriate measures, especially for sensitive groups in the event that Jordan's air quality index exceeds the approved international guidelines.

The website emulates the global website of the air quality index that includes more than 80 countries where the air quality index is calculated in real time for more than 10,000 stations in the world and the readings are updated to calculate the indicators every hour periodically.

The Air Quality Index (AQI) is a color index linked to numerical values, which is mostly utilized by government institutions and agencies concerned with the protection of the environment, parties interested in the environment as well as citizens interested in knowing the air quality in a specific location. Changes in AQI means different concentrations of ambient air pollutants where each group is distinguished with a color and description. The green color indicates that the air quality is good, yellow indicates that the air quality is moderate while the orange color indicates that the air may affect sensitive groups and the red color indicates that the air is not healthy. As for the violet color, it indicates that the air is very unhealthy, and finally the highest indication is brown which means that the air quality is dangerous.

The results of observing Jordan's Ministry of Environment website shows that the air quality index in all 12 monitoring stations of the Kingdom ranges between green (good) and yellow (moderate). Whereas, during heavy traffic or dessert dust storms, the AQI changes to darker colors.

1.10 Stations

All twelve stations are uniform in external architecture and were designed to provide both functionality as well as nice exterior aesthetics. The shelters are made from sheet steel which are fully insulated and protected from external heat. Monitoring devices and Analyzers were mounted internally in 19” racks and the shelter was fitted with two air conditioning units to ensure an optimum temperature of 25 degrees is maintained. Finally, a six pillar sandstone block fence encloses the steel shelter for maximum security. A standard station is shown in (Figures 1.2 and 1.3).

Figure (1.2) Station from inside

Figure (1.3) Station from outside

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RESULTS

Table (2.1) shows the annual averages of air pollutants that were monitored in all stations during the period from 1/1/2019 to 31/12/2019,, **Red color** indicates that this value exceeded the Jordanian Limits 1140/2006.

Table (2.1): Yearly Averages of pollutants in all stations.

#	Station	Short Name	PM10 µg/m^3	NO_2 ppb	SO_2 ppb	CO ppb	O_3 ppb
		Average as in Jordanian Limits 1140/2006					
			70 µg/m^3	50 ppb	40 ppb	Not Found	Not Found
Amman							
1	King Hussein Gardens	KHG	36.1	9.2	4.4	-	39.7
2	Greater Amman Municipality	GAM	63.1	26.1	12	2682	
3	Northern Bus Station Tabarbour	TAB	63.4	42.2	-	1641	-
4	Marka / Mahata	MAH	70.6	41.7	13.2	-	-
5	University street Sweileh	UNI	52.7	29.8	-	-	-
6	King Abdullah II Industrial City / Sahab	KAC	63.7	19.3	9.8	-	-
7	Yarmuk	YAR	64.3	21	4.7	-	-
Zarqa							
8	Health Center Wadi Hajjar	HAJ	65.5	33.7	18.9	1791	-
9	Main slaughter house Masane' Zone	MAS	55.4	20.1	8.9	-	-
10	Hashemite Hall	ABK/HH	58.6	15.5	10.4	-	-
Irbid							
11	AL Hassan Sport City	HSC	47.7	19.5	-	1939	-
12	Al Barha street	BAR	37.6	20.5	7.3	-	47.2

Table (2.2) shows the number of exceedances each according to what is required in technical specification number JS1140 for the year 2006 regarding the ambient air quality.

Table (2.2): Number of exceedances in all stations.

			PM10	NO_2	NO_2	SO_2	SO_2	CO	CO	O_3	O_3
Station			24hr AVG	24hr AVG	1hr MAX/ 24hr	24hr AVG	1hr MAX/ 24hr	8hr AVG MAX/ 24hr	1hr MAX/ 24hr	8hr AVG MAX/ 24hr	1hr MAX/ 24hr
Limits			120 $\mu g/m^3$	80 ppb	210 ppb	140 ppb	300 ppb	9000 ppb	26 ppm	80 ppb	120 ppb
Number of allowed exceedances			3	3	3	3	3	3	3	-	-
Amman											
1	King Hussein Gardens	KHG	10	-	-	-	-	-	-	-	1
2	Greater Amman Municipality	GAM	26	-	-	-	-	-	-	-	-
3	Northern Bus Station Tabarbour	TAB	25	7	-	-	-	-	-	-	-
4	Marka – Mahata	MAH	47	19	33	-	-	-	-	-	-
5	University street Sweile	UNI	12	-	-	-	-	-	-	-	-
6	King Abdullah II Industrial City/Sahab	KAC	31	-	1	-	-	-	-	-	-
7	Yarmuk	YAR	27	-	-	-	-	-	-	-	-
Zarqa											
8	Health Center Wadi Hajjar	HAJ	35	-	-	-	-	-	-	-	-
9	Main slaughter house Masane' Zone	MAS	12	-	-	-	-	-	-	-	-
10	Hashemite Hall	ABK/HH	17	-	-	-	-	-	-	-	-
Irbid											
11	AL Hassan Sport City	HSC	9	-	-	-	-	9	-	-	-
12	Al Barha street	BAR	4	-	-	-	-	-	-	-	-

2.1 Particulate Matters (PM10)

Particulate Matter with aerodynamic diameter ≤ 10 microns (PM10) They are coarse suspended particles and are less than or equal to 10 μg/m^3 in diameter. The smaller the particles, the more they can reach the lungs and can cause several health problems, especially for people who already suffer from respiratory diseases such as asthma and bronchitis. Particles can also affect the immune system, thereby reducing the body's ability to fight infection. Epidemiological research recently indicated that inhaled particles may lead to high blood pressure, strokes, and lung cancer, thus increasing annual death rates.

Allowable limits for particle emissions with an effective diameter of ≤10 micron (PM10) in Jordanian Technical Rule No. 1140 of 2006:

- **Annual average is 70 μg/m^3**
- **The daily average (24 hours) is 120 (μg/m3), which is not to be exceeded for more than three times in a 12-month period.**

Sandstorms and atmospheric instabilities cause high concentrations of particulate matters with an effective diameter ≥10 micron (**PM10**). Also, Emissions from domestic sources including vehicles, light industries and household heating contribute to the high level of PM10 readings.

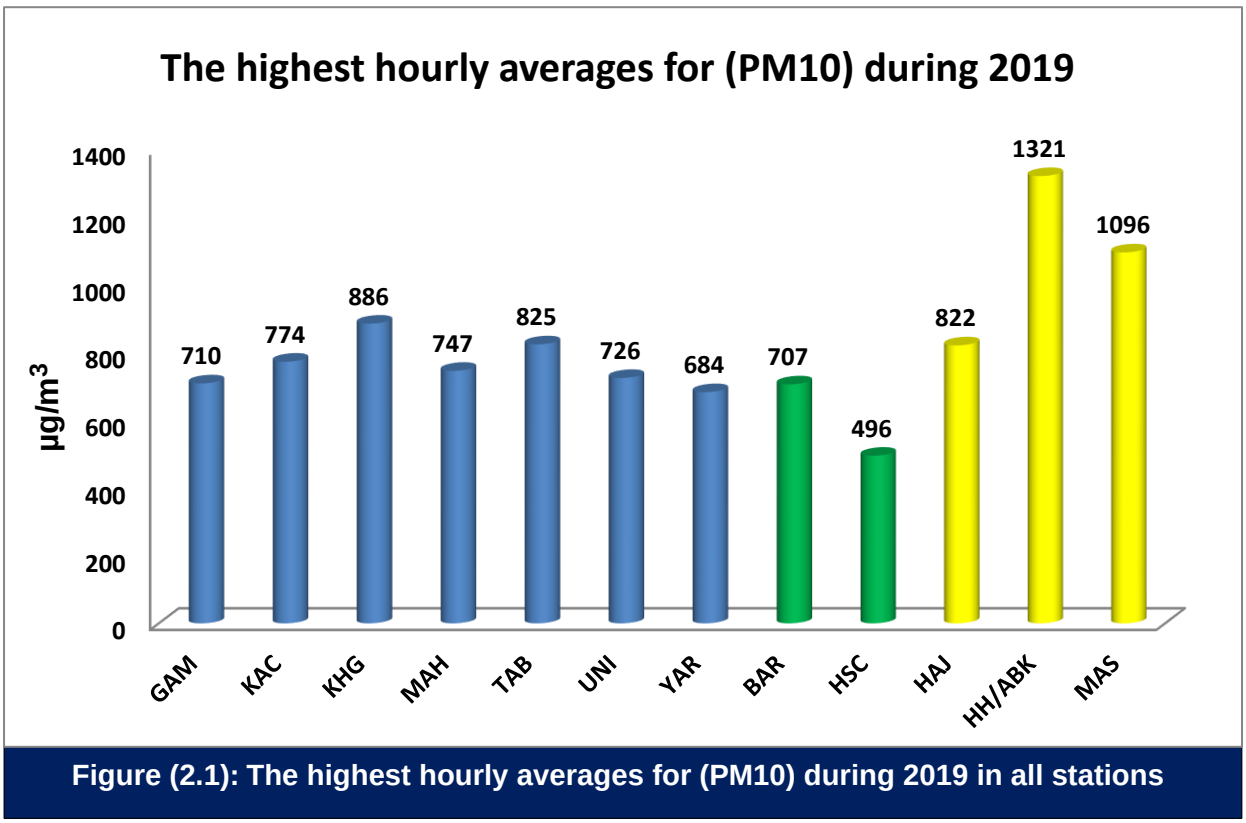


Figure (2.1): The highest hourly averages for (PM10) during 2019 in all stations

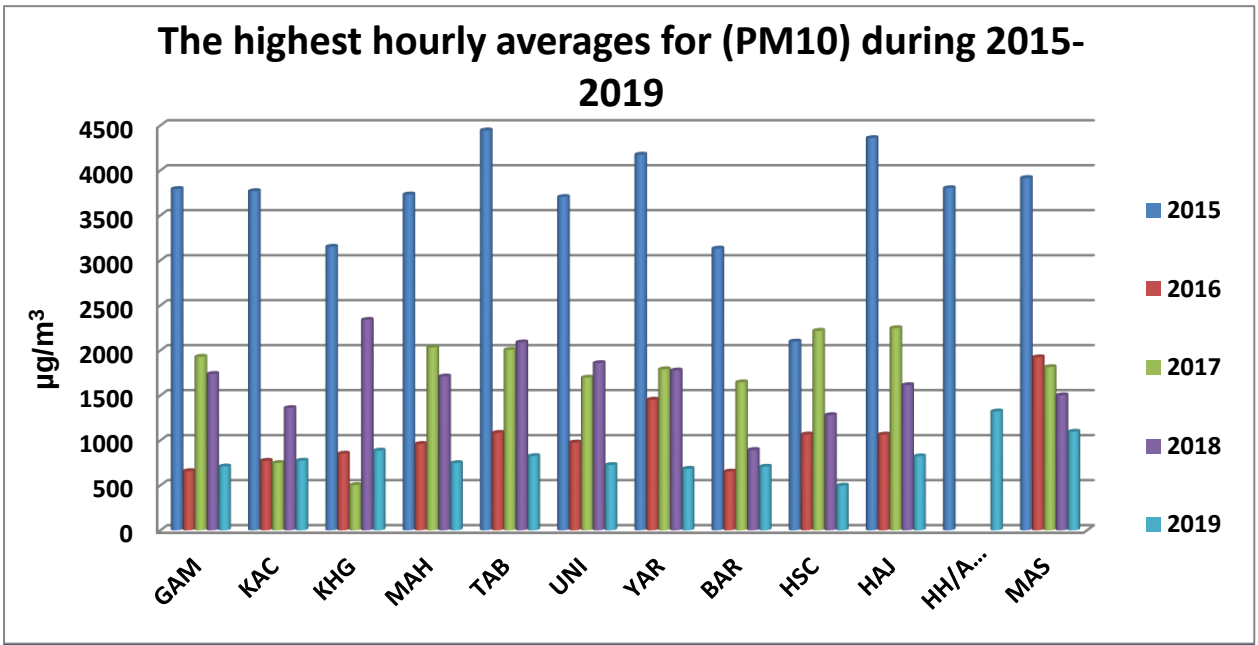


Figure (2.2): The highest hourly averages for (PM10) during 2015-2019 in all stations

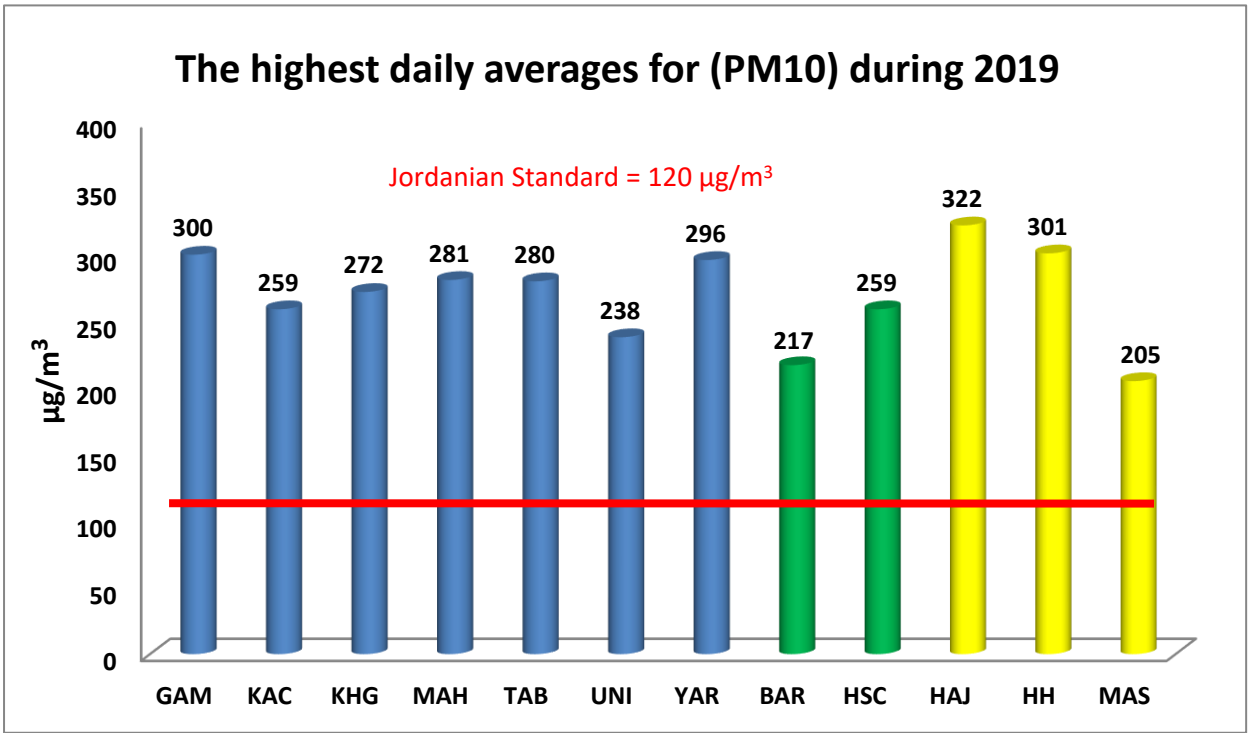


Figure (2.3): The highest daily averages for (PM10) during 2019 in all stations

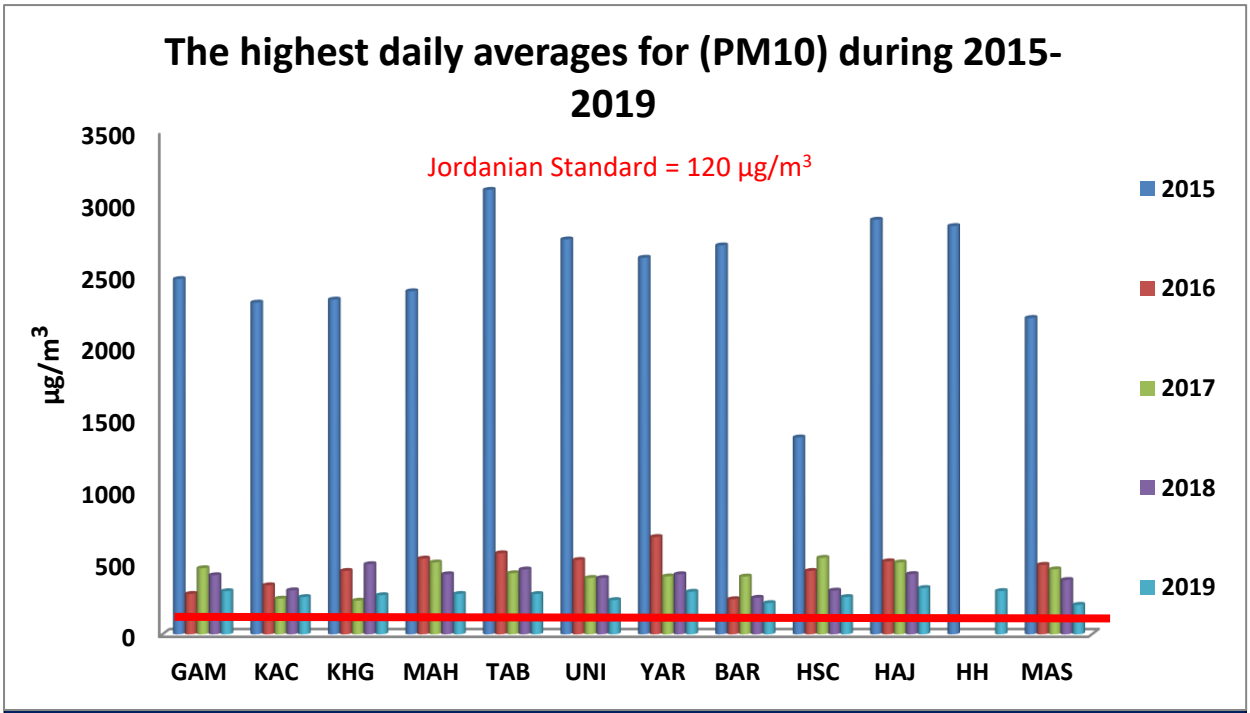


Figure (2.4): The highest daily averages for (PM10) during 2015-2019 in all stations

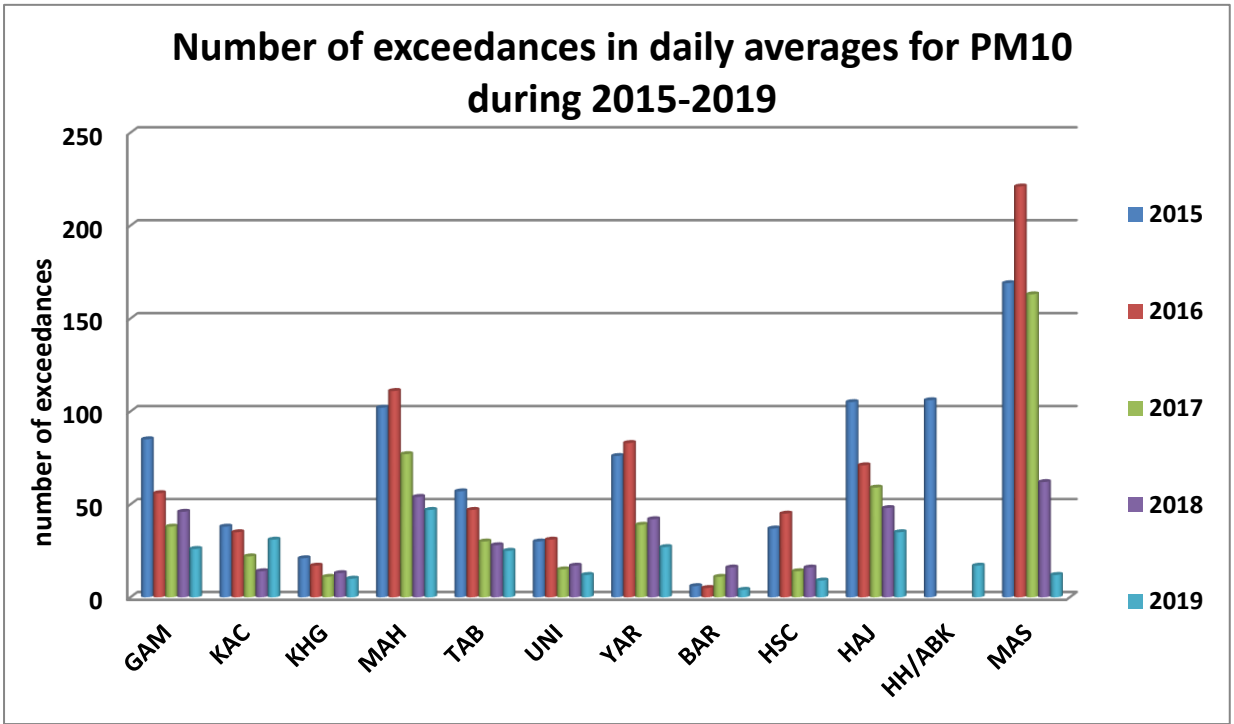


Figure (2.5): Number of exceedances in daily averages for PM10 during 2015-2019 in all stations.

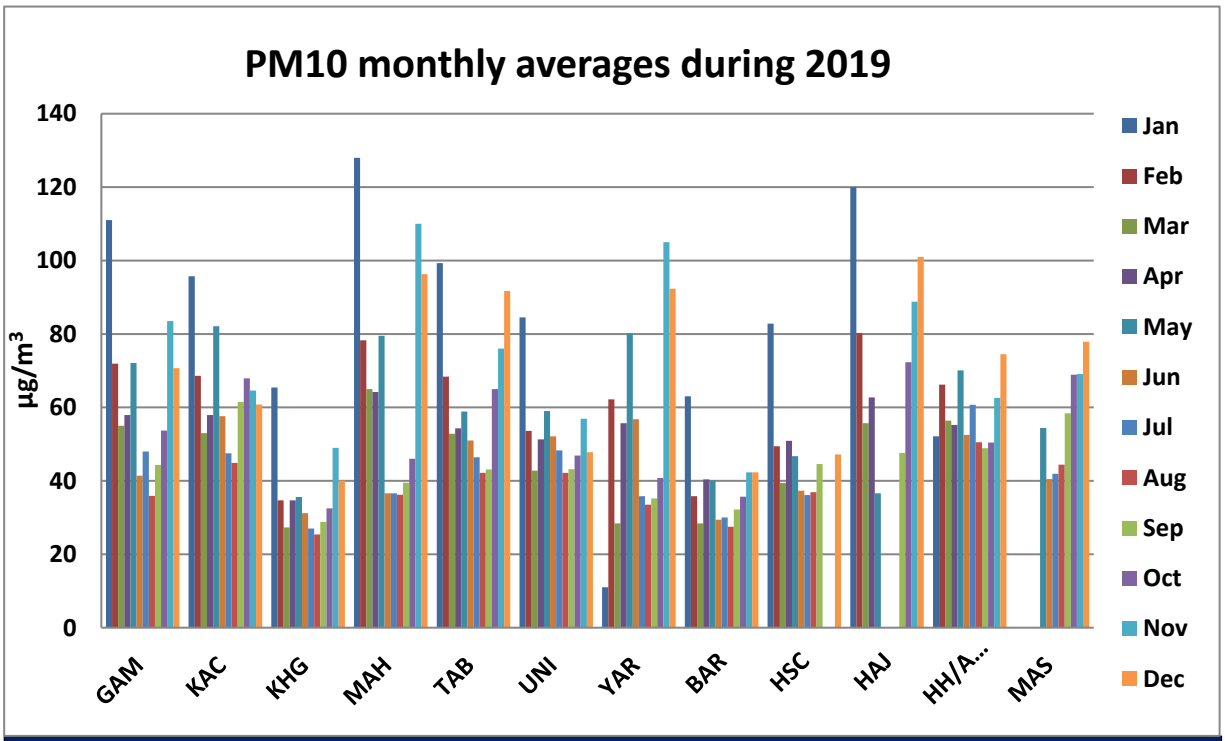


Figure (2.6): PM10 monthly averages during 2019 in all stations.

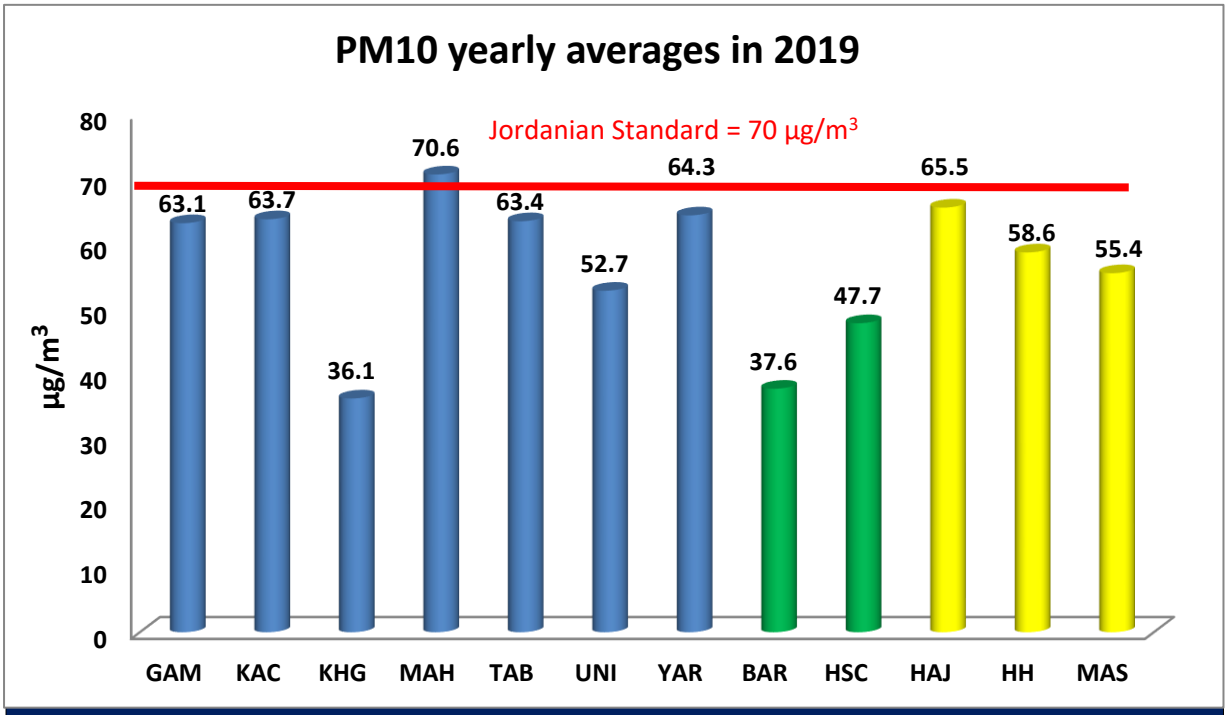


Figure (2.7): PM10 yearly averages in 2019 in all stations.

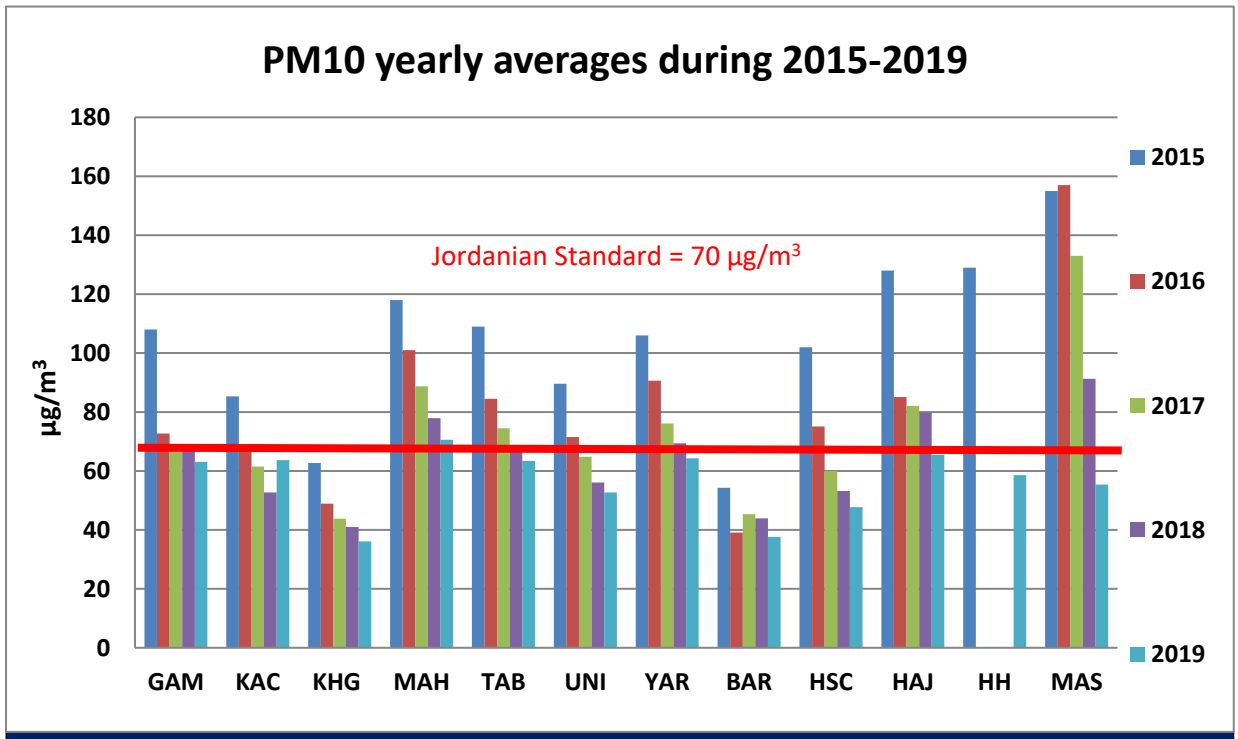


Figure (2.8): PM10 yearly averages during 2015-2019 in all stations.

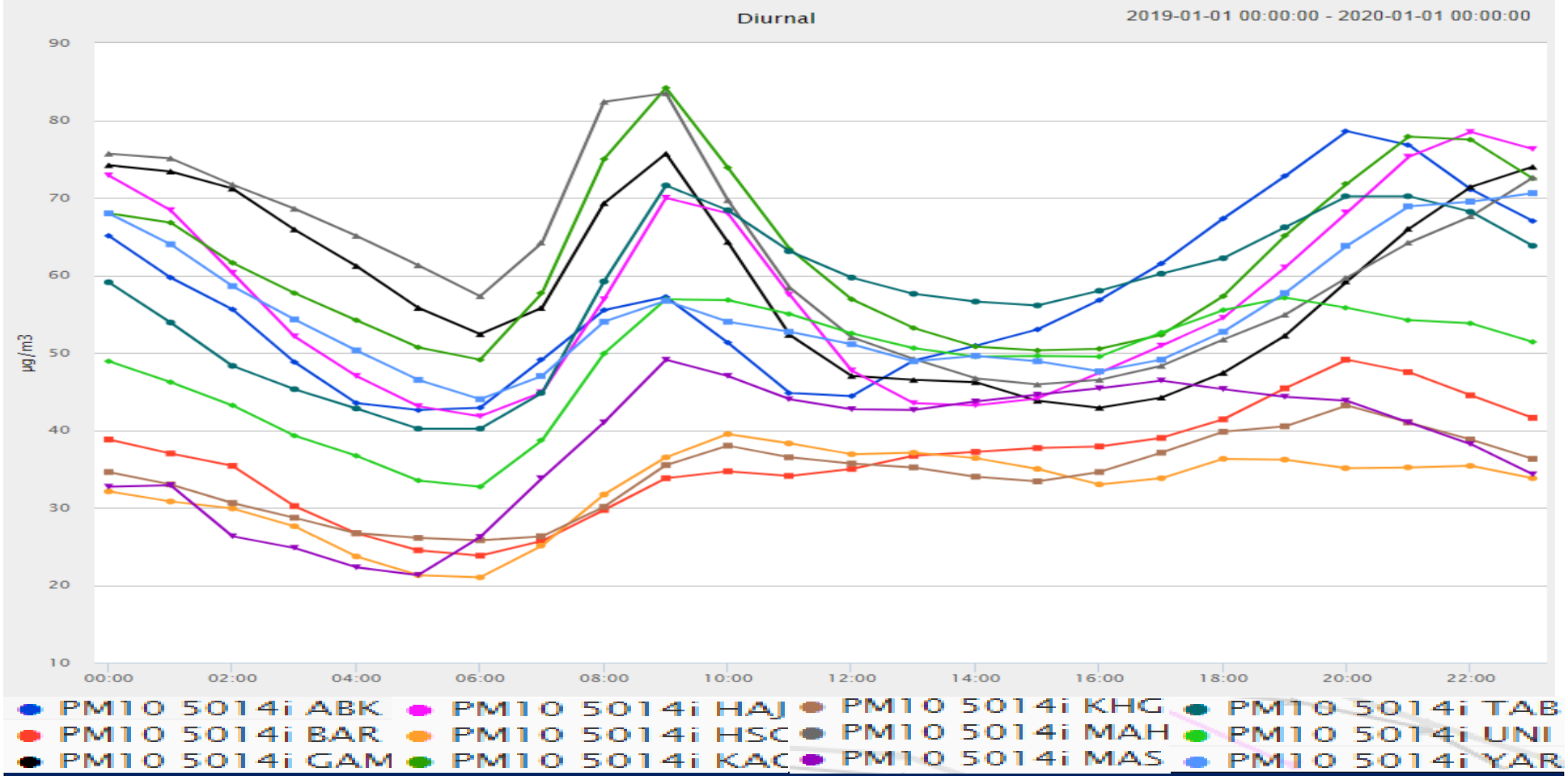


Figure (2.9): The average value in each hour of the day in all stations of the Particulate Matter (PM10)

The results, as shown in Figure (2.9), indicate that the highest daily readings of PM10 occur during the peak traffic period, around (8-9am) in the morning and (7-8) pm in the evening.

2.2 Nitrogen dioxide (NO_2)

Nitrogen dioxide (NO_2) is a gas that adversely affects the respiratory system. The Jordanian Standard allows three 1-hour average concentrations greater than 210 ppb a 12-month period. The 24-hour average Jordanian Standard for ambient air quality is 80 ppb while the yearly average is 50 ppb.

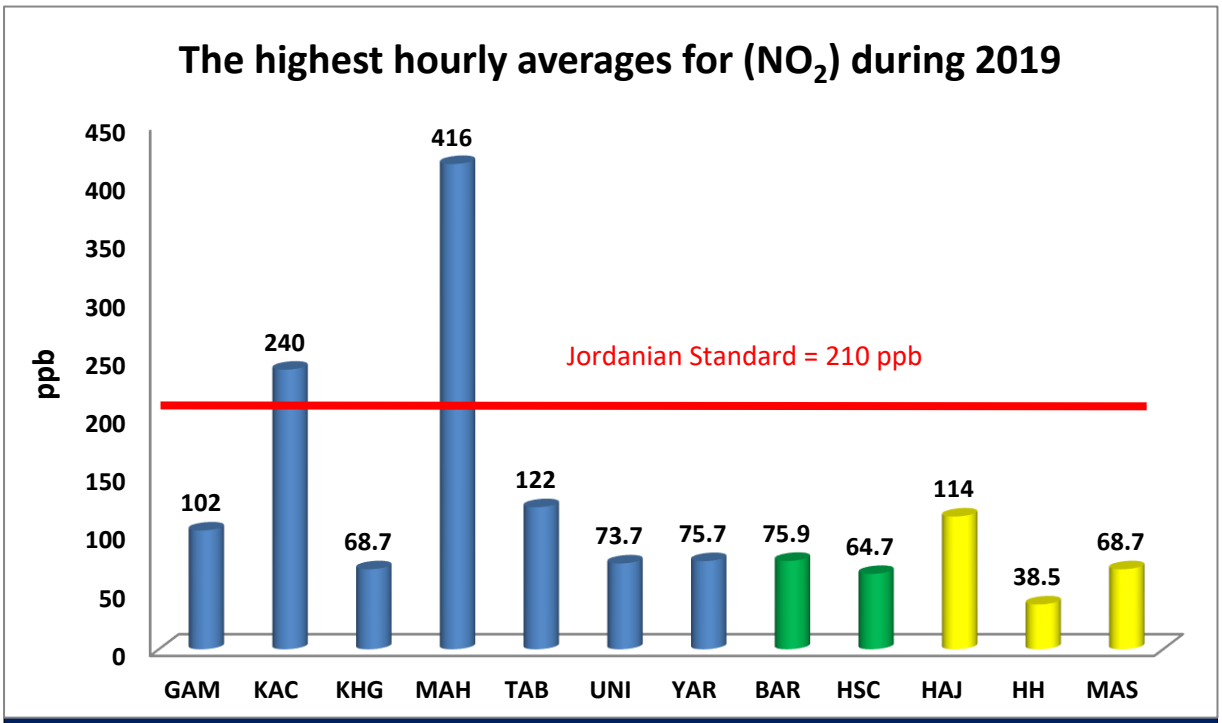


Figure (2.10): The highest hourly averages for (NO_2) during 2019 in all stations

The results of monitoring the ambient air quality showed that the hourly averages of **NO_2** gas were within the limits allowed in the Jordanian standard (1140/2006) in most of the monitoring stations, where only two exceeds were detected in King Abdullah II Industrial Station and Marka Station in Amman as shown in figure (2.10) above.

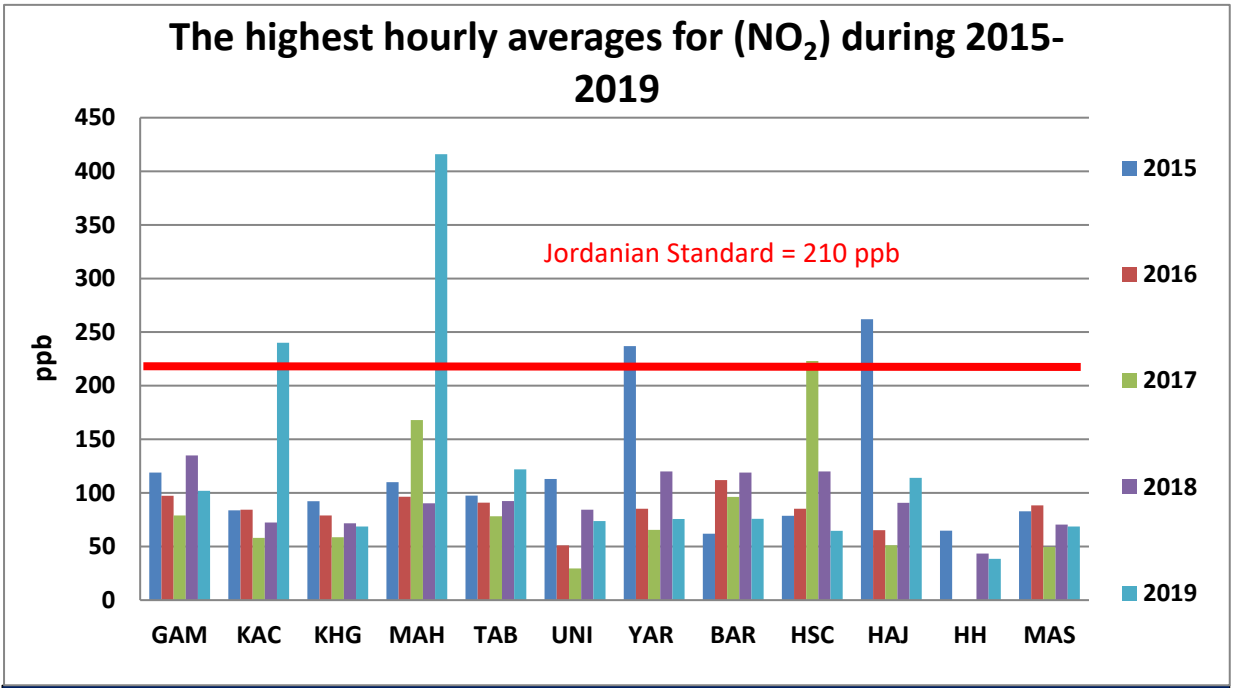


Figure (2.11): The highest hourly averages for (NO_2) during 2015-2019 in all stations

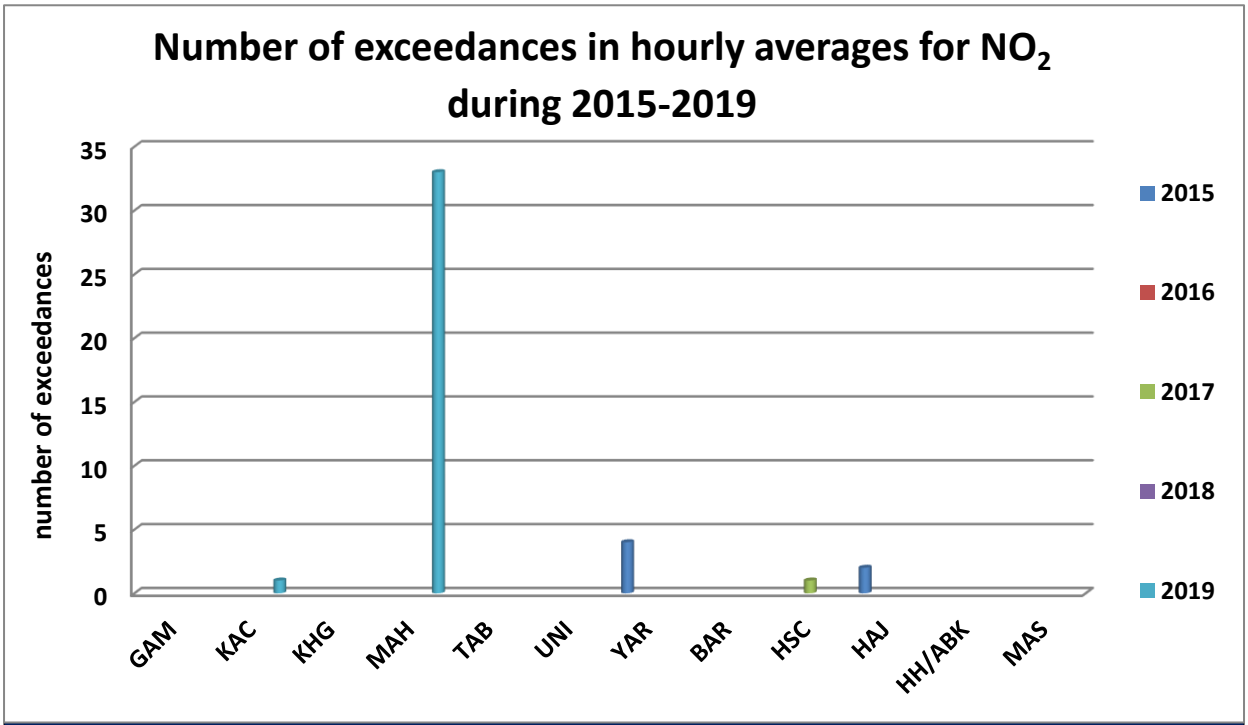


Figure (2.12): Number of exceedances in hourly averages for NO_2 during 2015-2019 in all stations

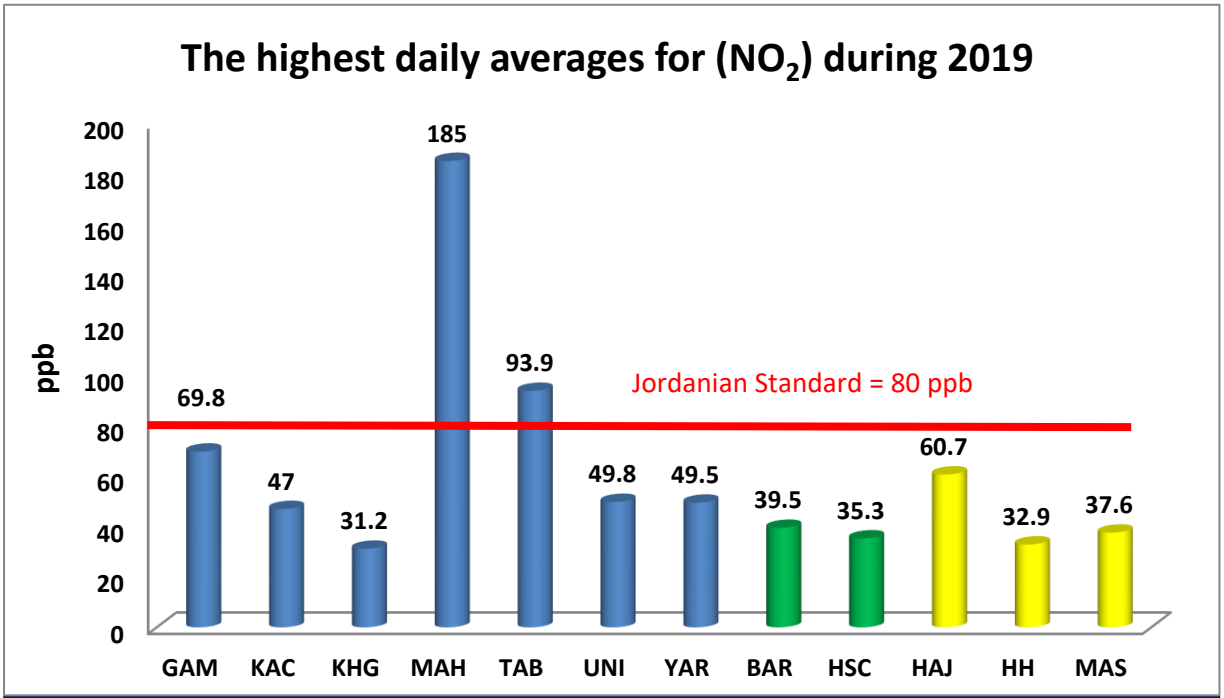


Figure (2.13): The highest daily averages for (NO_2) during 2019 in all stations

The results of monitoring the ambient air quality showed that the daily averages of **NO_2** gas were within the limits allowed in the Jordanian standard (1140/2006) in the majority of monitoring stations, where only two exceeds were observed in Tabarbour and Mahatta stations in Amman as shown in the figure (2.13). The highest daily **NO_2** gas average was 185 ppb at Mahatta Station.

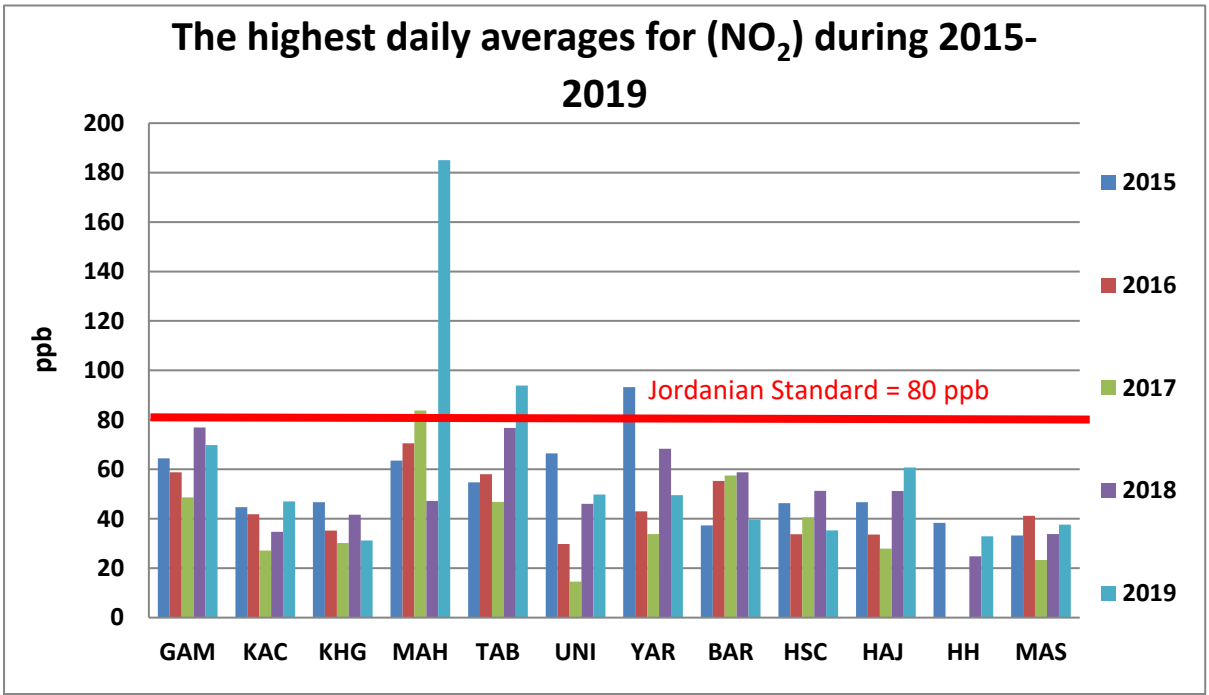


Figure (2.14): The highest daily averages for (NO_2) during 2015-2019 in all stations

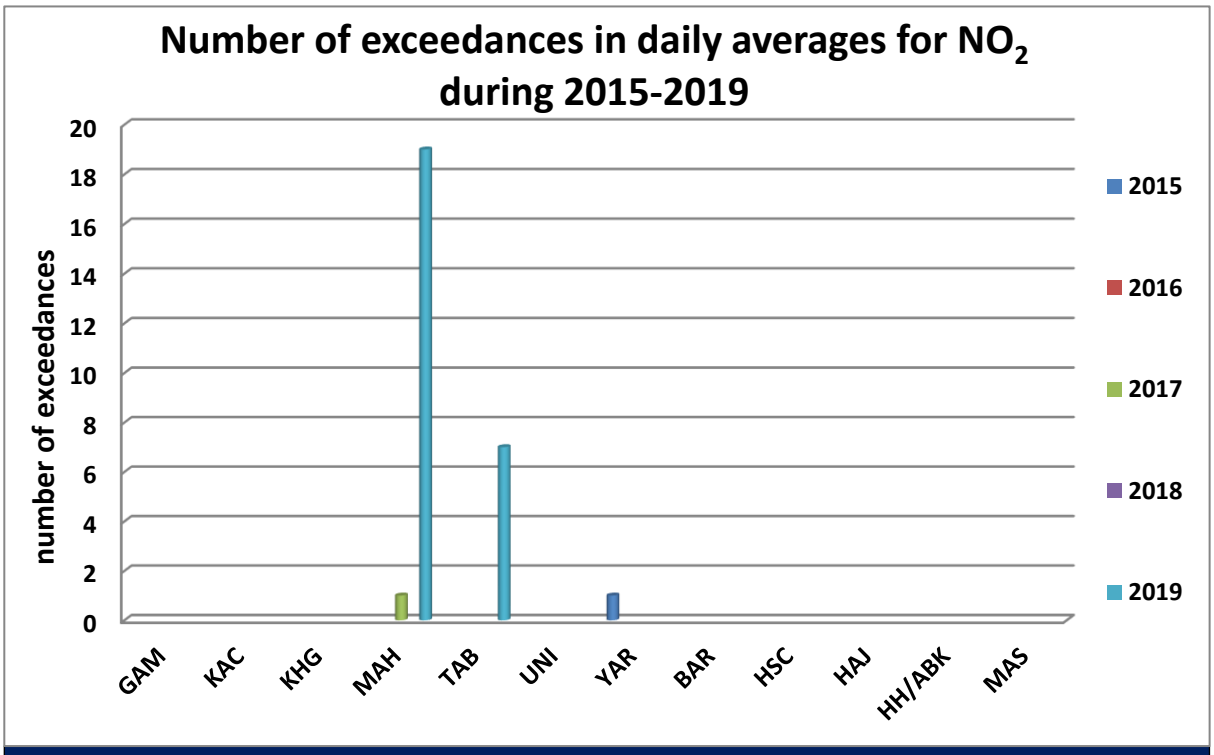


Figure (2.15): Number of exceedances in daily averages for NO_2 during 2015-2019 in all stations.

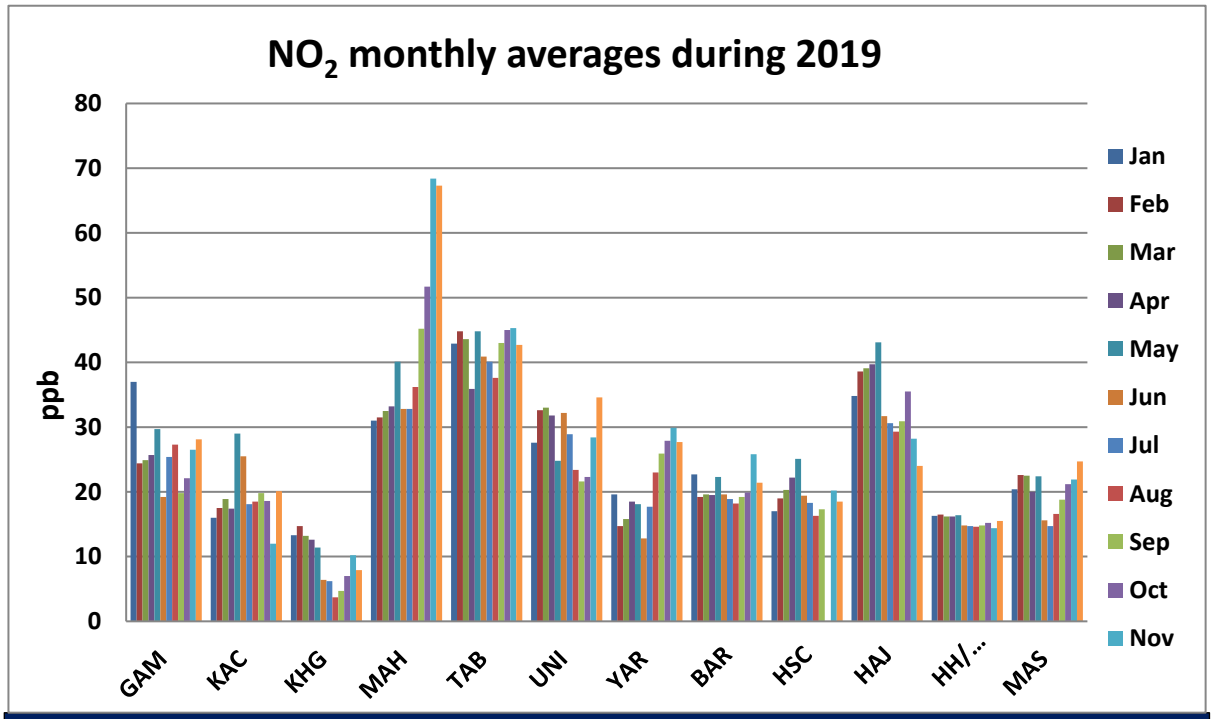


Figure (2.16): NO_2 monthly averages during 2019 in all stations.

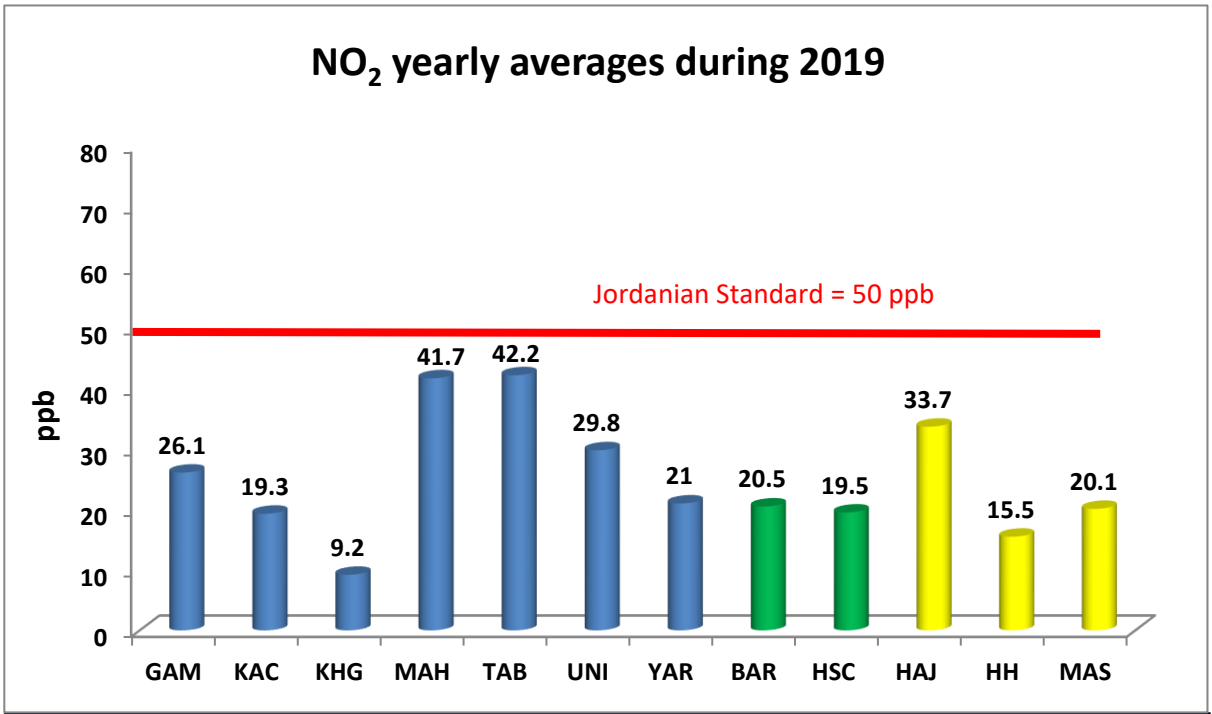


Figure (2.17): NO_2 yearly averages in 2019 in all stations.

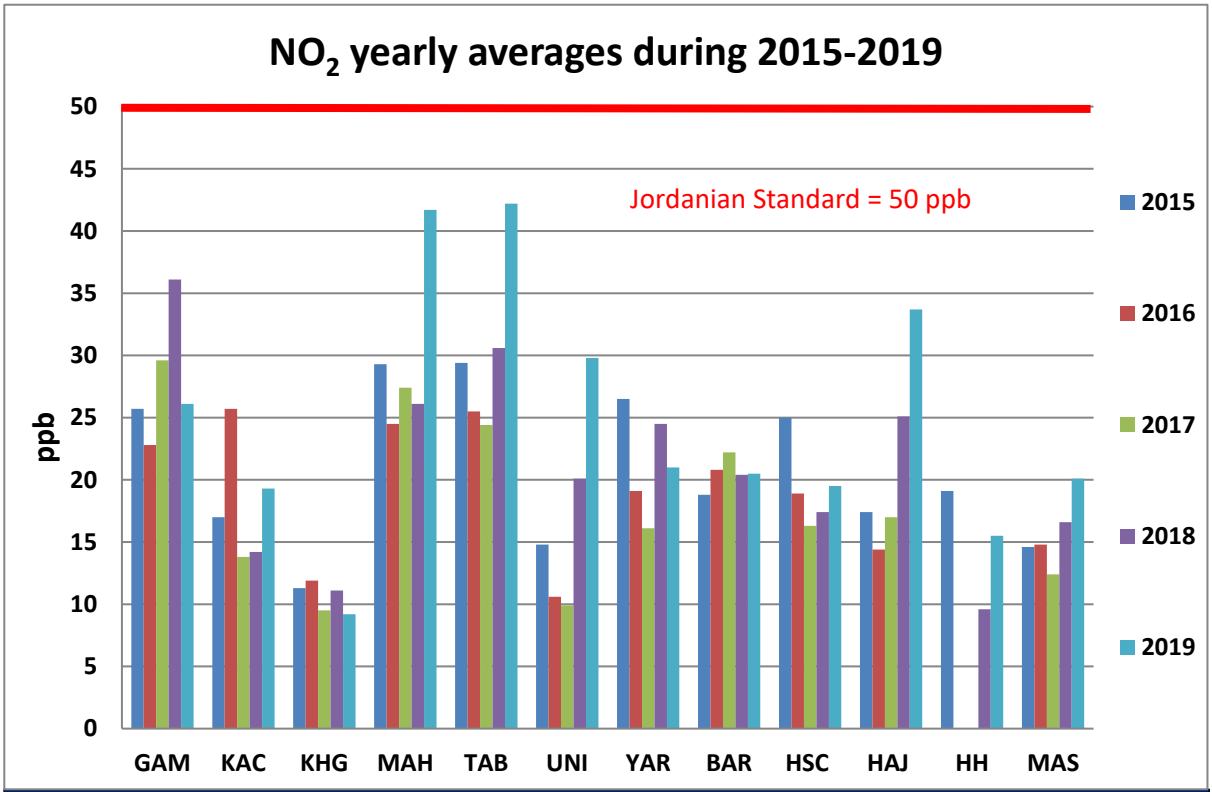


Figure (2.18): NO_2 yearly averages during 2015-2019 in all stations.

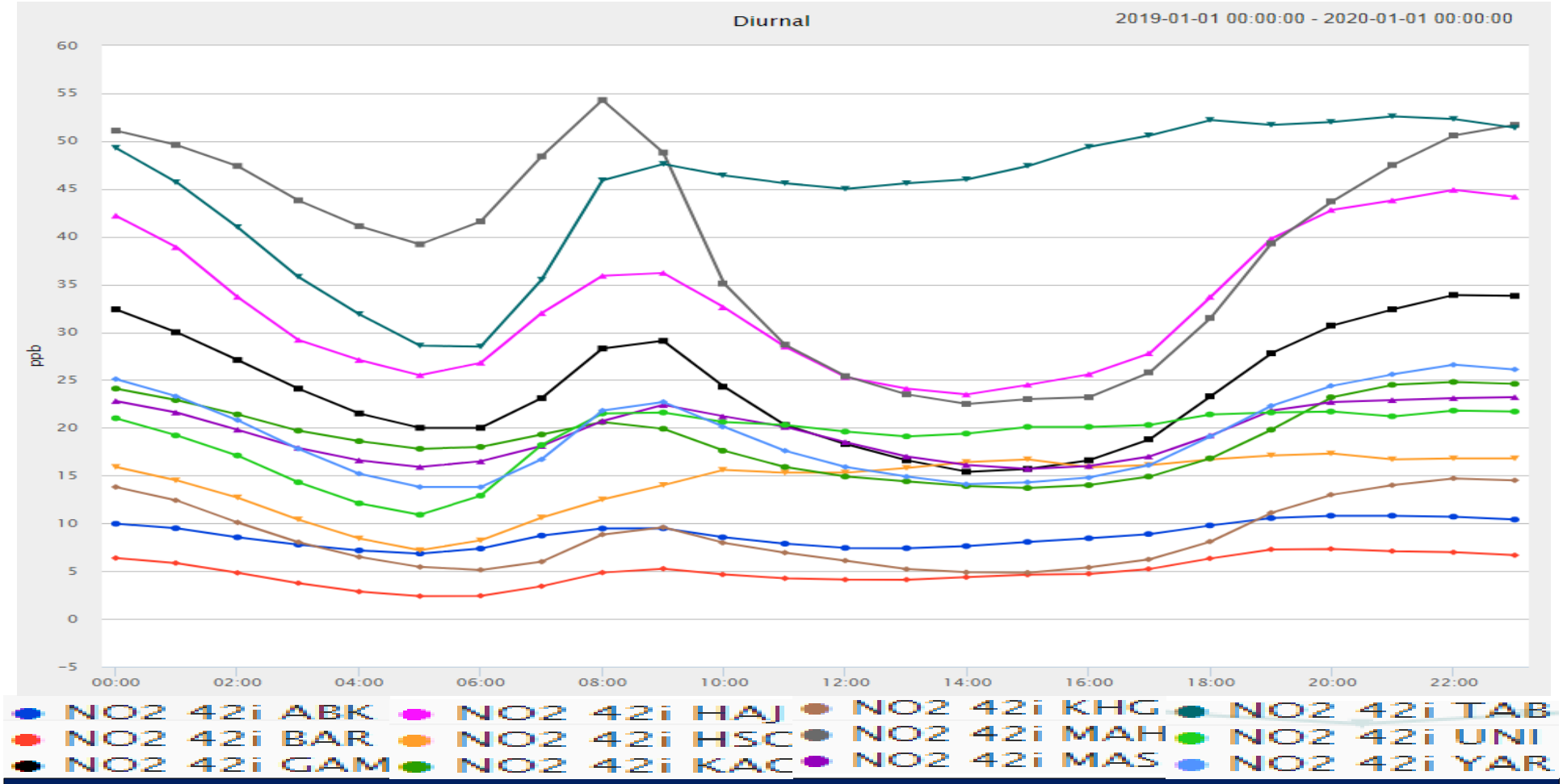


Figure (2.19): The average value in each hour of the day in all stations of Nitrogen Dioxide (NO_2).

The highest daily NO_2 readings appear to be around midnight as shown in figure (2.19).

2.3 Sulfur Dioxide SO_2

Sulphur dioxide (SO_2) is a toxic gas known to have adverse impacts on the respiratory system. It irritates the nose, throat and lungs and it could cause bronchitis.

- The Jordanian Standard allows three 1-hour average concentrations greater than 300 ppb in a 12-month period.
- The 24-hour average Jordanian Standard for ambient air quality is 140 ppb while the yearly average is 40 ppb.

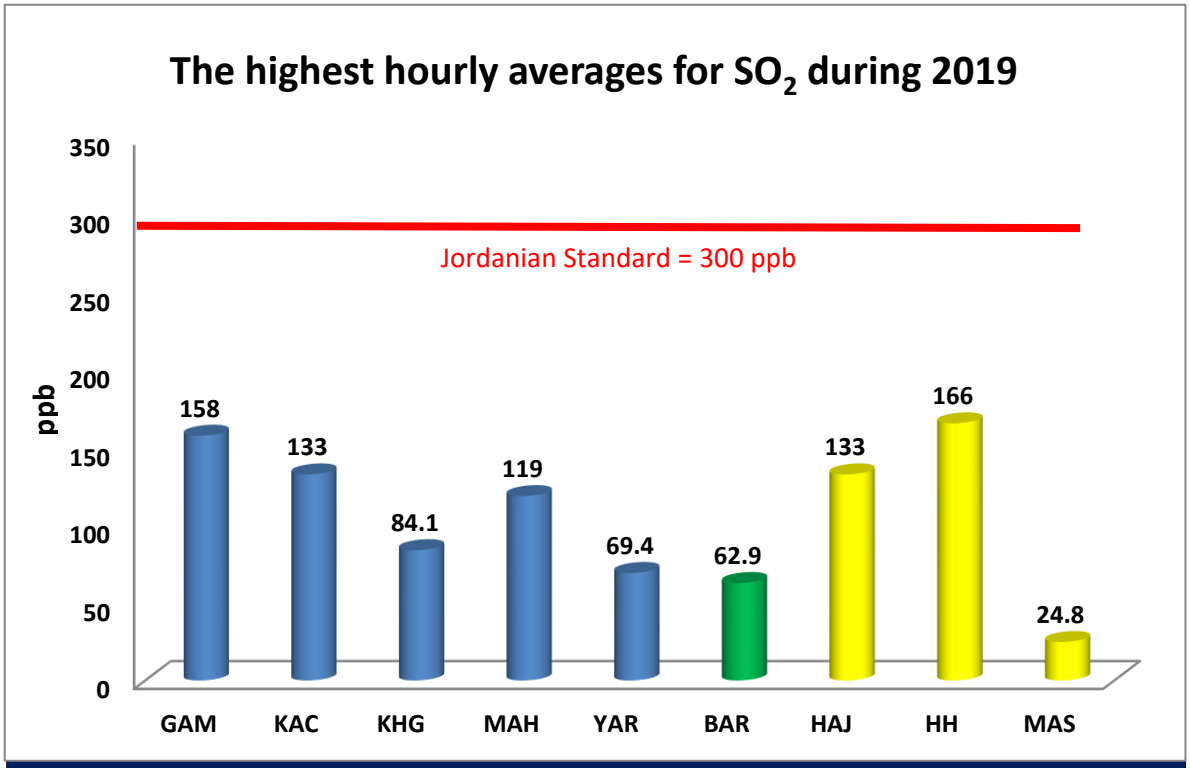


Figure (2.20): The highest hourly averages for SO_2 during 2019

The results of monitoring the ambient air quality showed that the hourly averages of SO_2 were within the limits allowed in the Jordanian standard (1140/2006) in all monitoring stations, Where no excess was observed as shown in the figure (2.20). The highest hourly average of SO_2 gas reached 166 ppb at the Hashemite Hall Station, Zarqa.

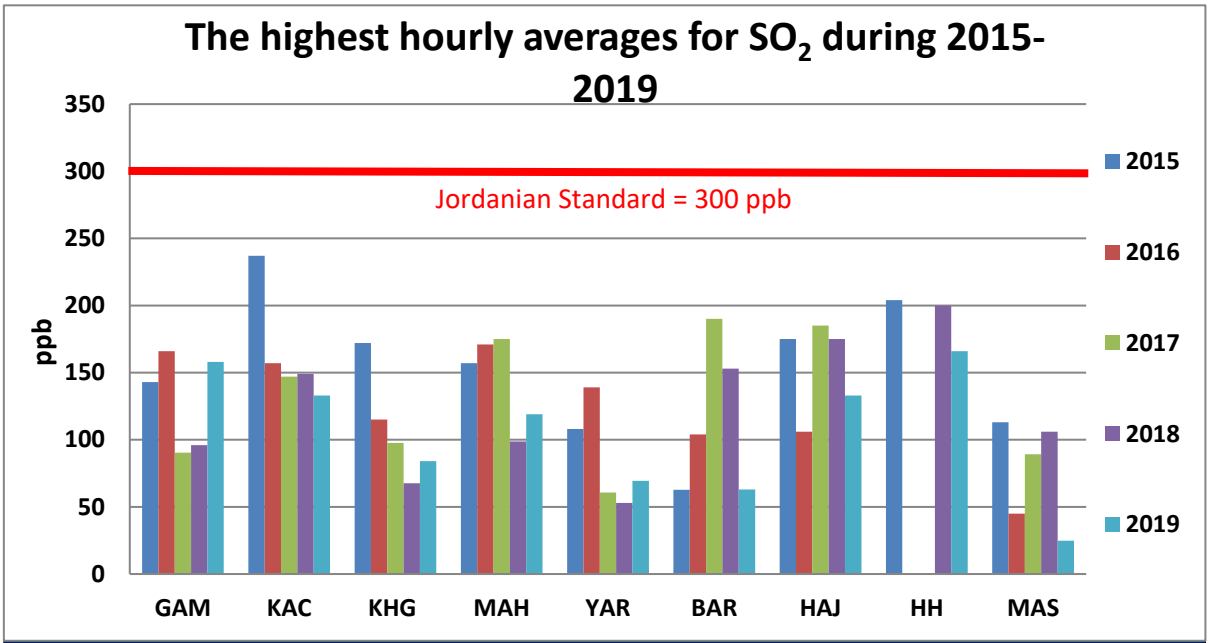


Figure (2.21): The highest hourly averages for SO_2 during 2015-2019

The results of monitoring the ambient air quality showed that the level of sulfur dioxide gas for the hourly averages was within the allowable limit in the Jordanian standard (1140/2006), as no excess was observed since the beginning of the monitoring process until now.

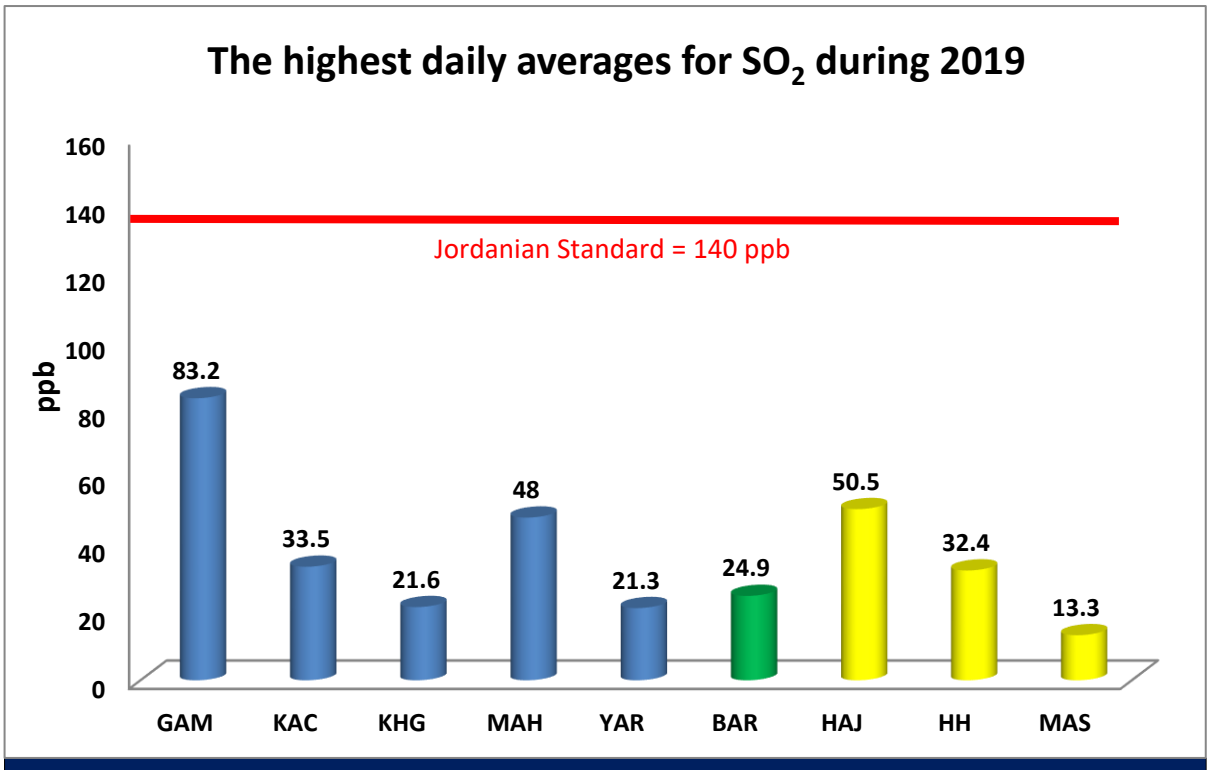


Figure (2.22): The highest daily averages for SO_2 during 2019.

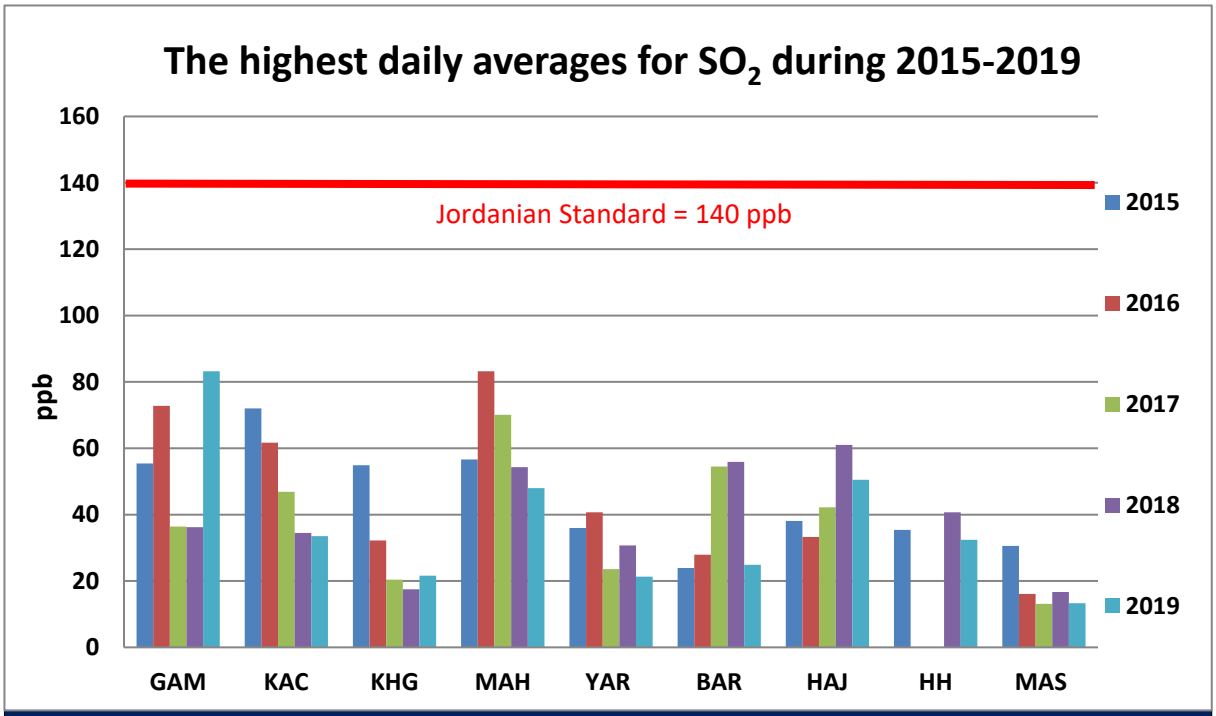


Figure (2.23): The highest daily averages for SO_2 during 2015-2019

The results of monitoring the ambient air quality showed that the level of sulfur dioxide concentration for daily rates was within the allowable limit in the Jordanian standard (1140/2006) which is equal to 140 ppb, as no excess has been monitored since the beginning of the monitoring process until now.

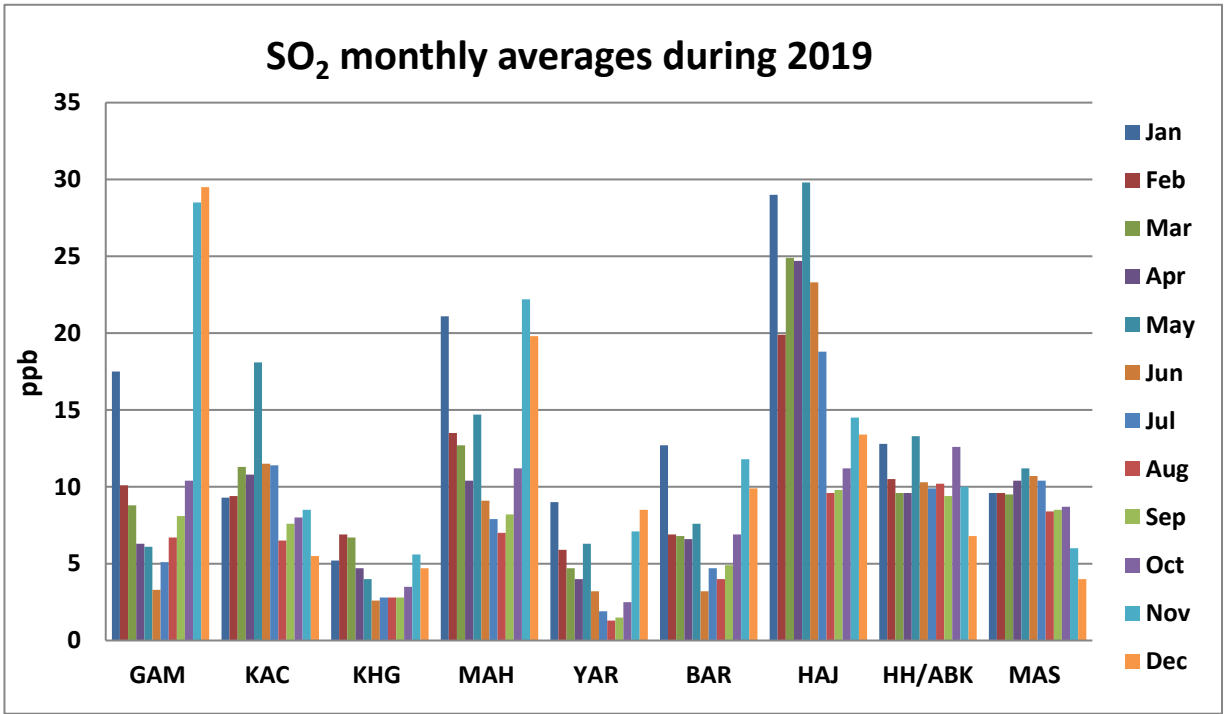


Figure (2.24):SO_2 monthly averages during 2019

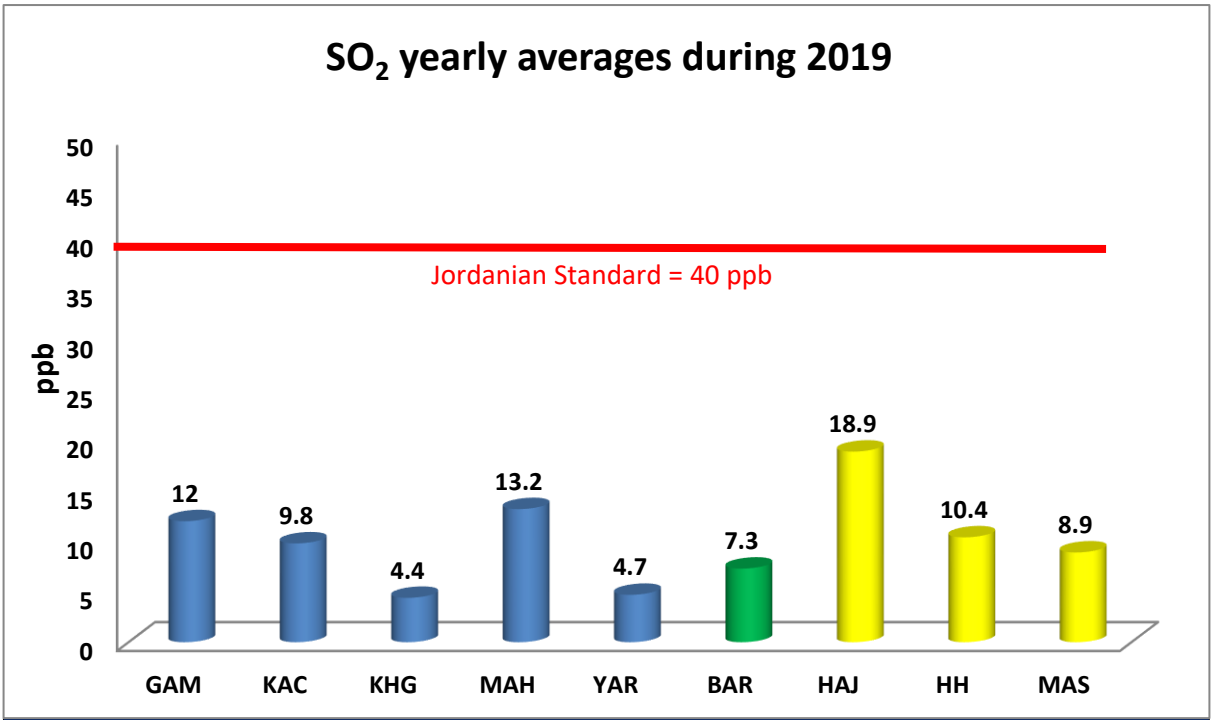


Figure (2.25): SO_2 yearly averages during 2019.

The results of monitoring the ambient air quality showed that the annual averages of SO_2 were within the limits allowed in the Jordanian standard (1140/2006) in all monitoring stations, where no excess was observed as shown in the figure (2.25), Where the highest annual average of SO_2 18.9 ppb at Wadi Al-Hajjar Station in Zarqa.

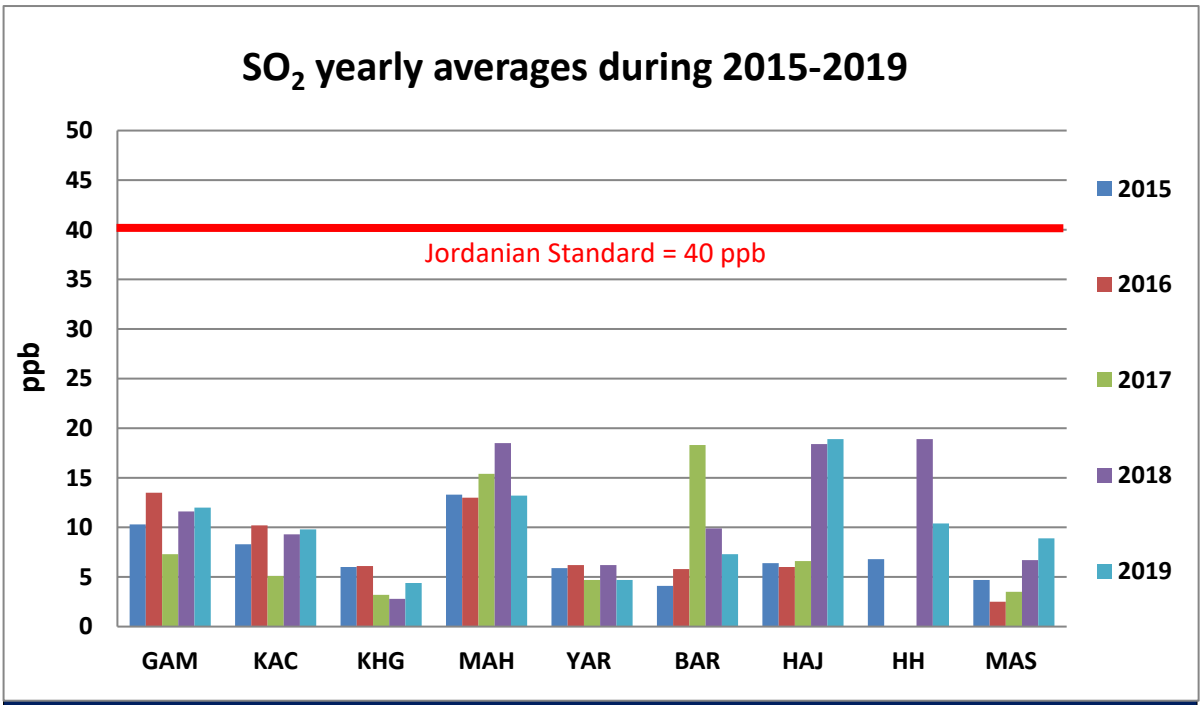


Figure (2.26): SO_2 yearly averages during 2015-2019.

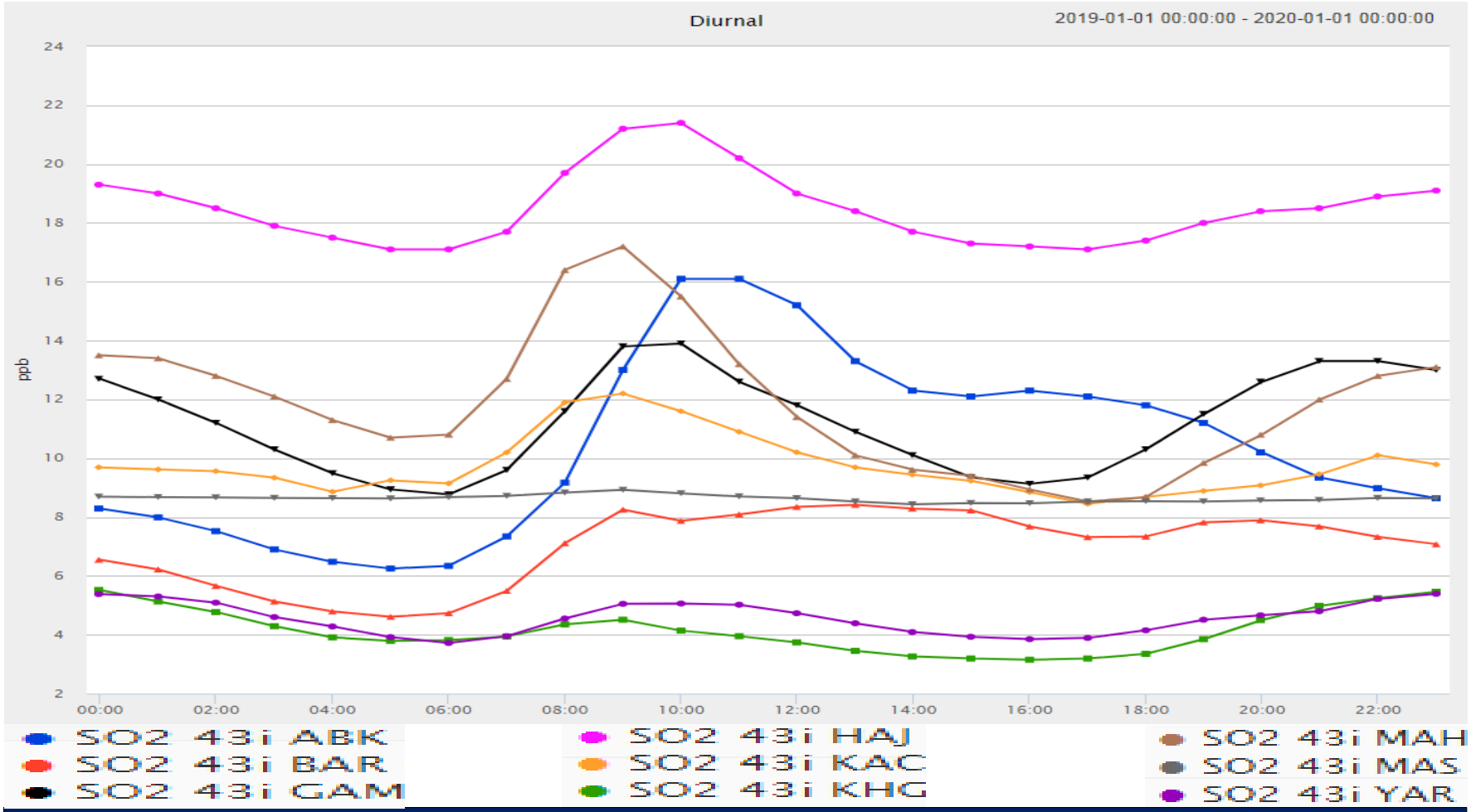


Figure (2.27): The average value in each hour of the day in all stations of Sulfur Dioxide (SO_2).

- The results indicate that the highest readings of SO_2 were recorded during the peak traffic period between 8-10 a.m. as in Figure (2.27).

2.4 Carbon monoxide CO

- Carbon monoxide (CO) is a toxic, colorless gas that limits the blood's ability to transport oxygen to cells and organs, resulting in suffocation at higher doses.
- .The Jordanian Standard allows three 1-hour average concentrations greater than 26 ppm in a 12-month period.
- The 8-hour average guideline is 9 ppm and there is no yearly average in the Jordanian Standard for ambient air quality.

Note that this gas is monitored only in 4 stations.

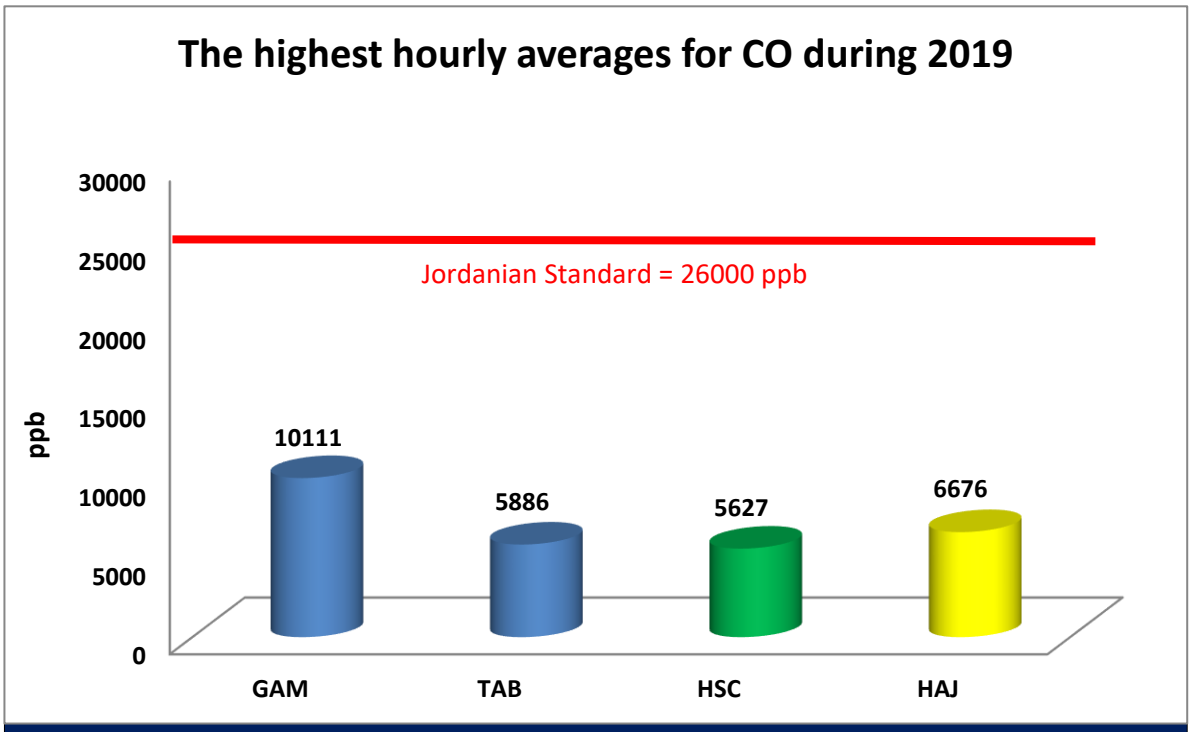


Figure (2.28): The highest hourly averages for CO during 2019

The results of monitoring the ambient air quality showed that the hourly averages of CO gas were within the limits allowed in the Jordanian standard (1140/2006) in all monitoring stations where no excess was observed as shown in the figure (2.28) where the highest hourly average of CO gas reached 10111 ppb at Greater Amman Municipality station in Amman.

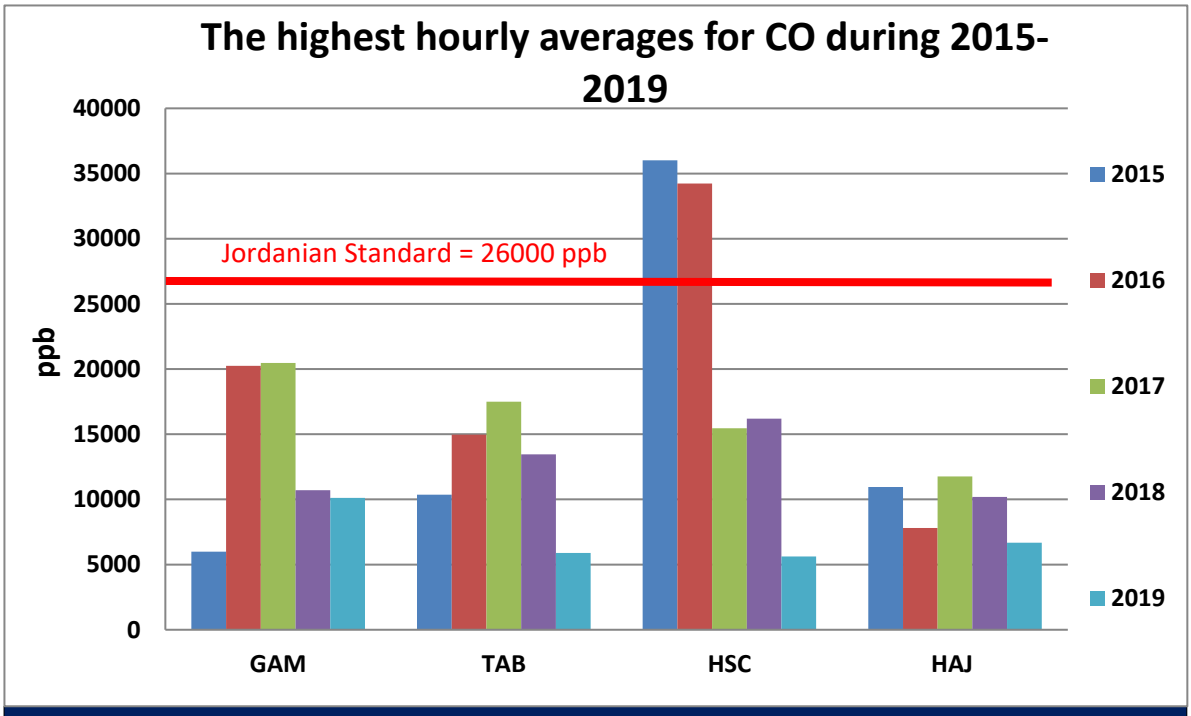


Figure (2.29): The highest hourly averages for CO during 2015-2019

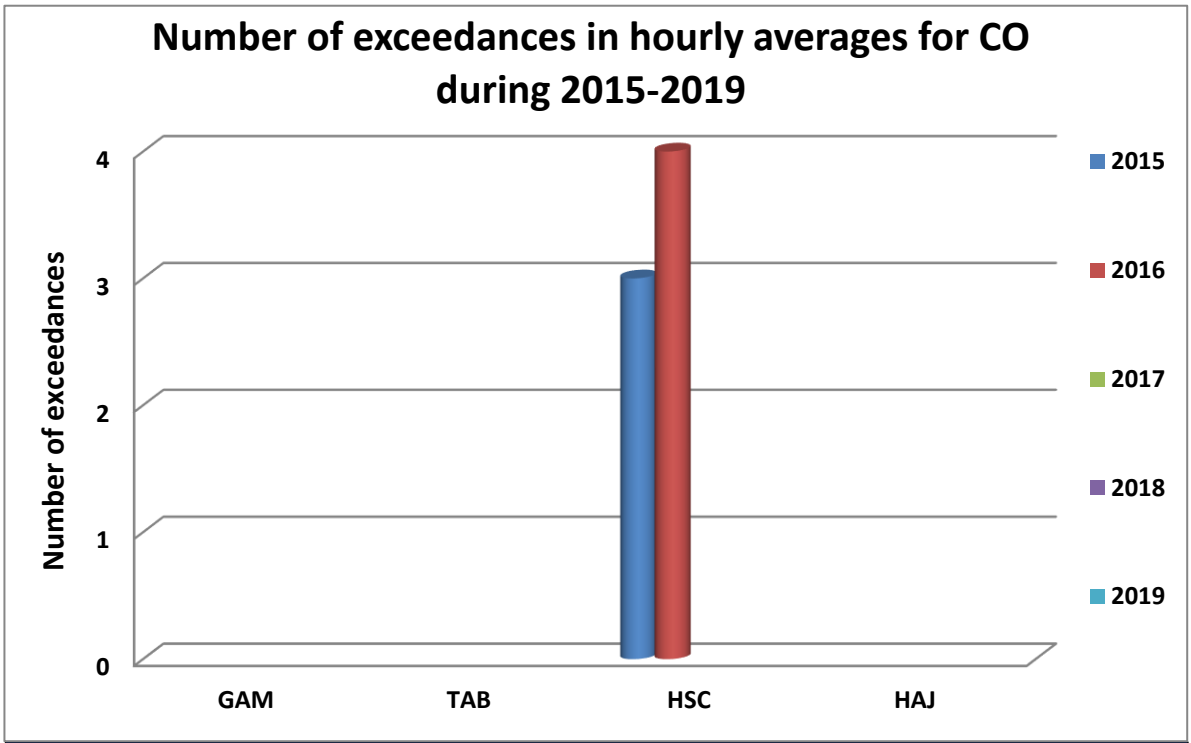


Figure (2.30): Number of exceedances in hourly averages for CO during 2015-2019

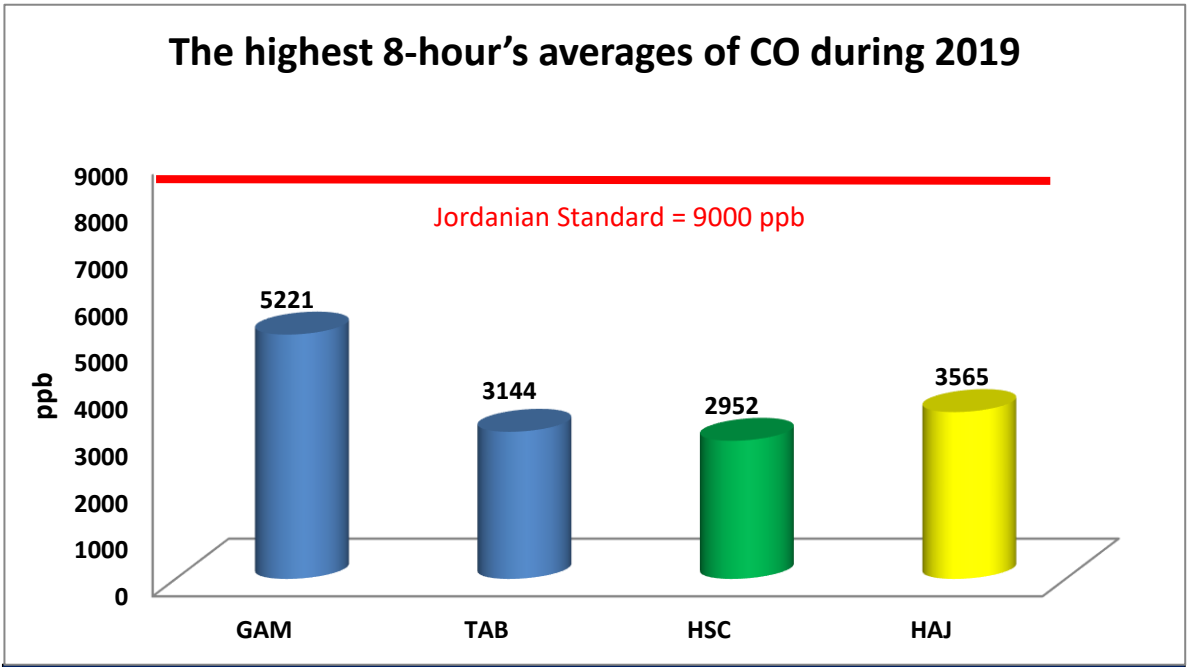


Figure (2.31): The highest 8-hour's averages of CO during 2019

The results of monitoring the ambient air quality showed that the daily averages of CO gas were within the limits allowed in the Jordanian standard (1140/2006) in all monitoring stations where no excess was observed as shown in the figure (2.31) where the highest daily average was 5221 ppb at Greater Amman Municipality station in Amman

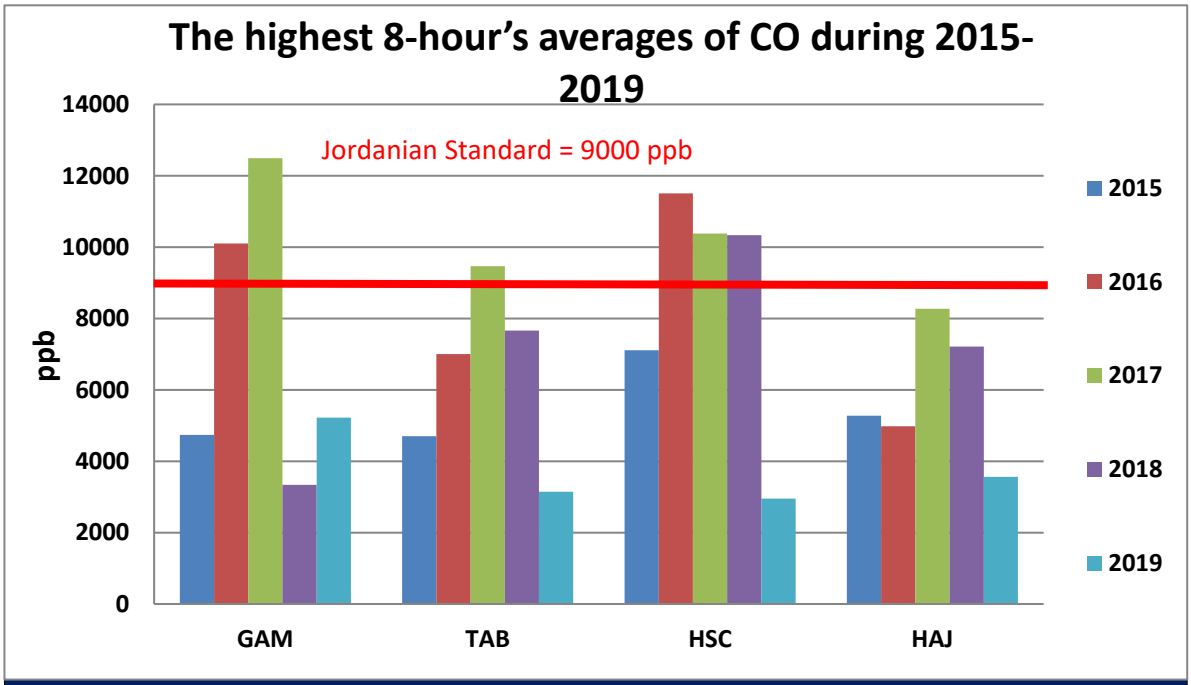


Figure (2.32): The highest 8-hour's averages of CO during 2015-2019

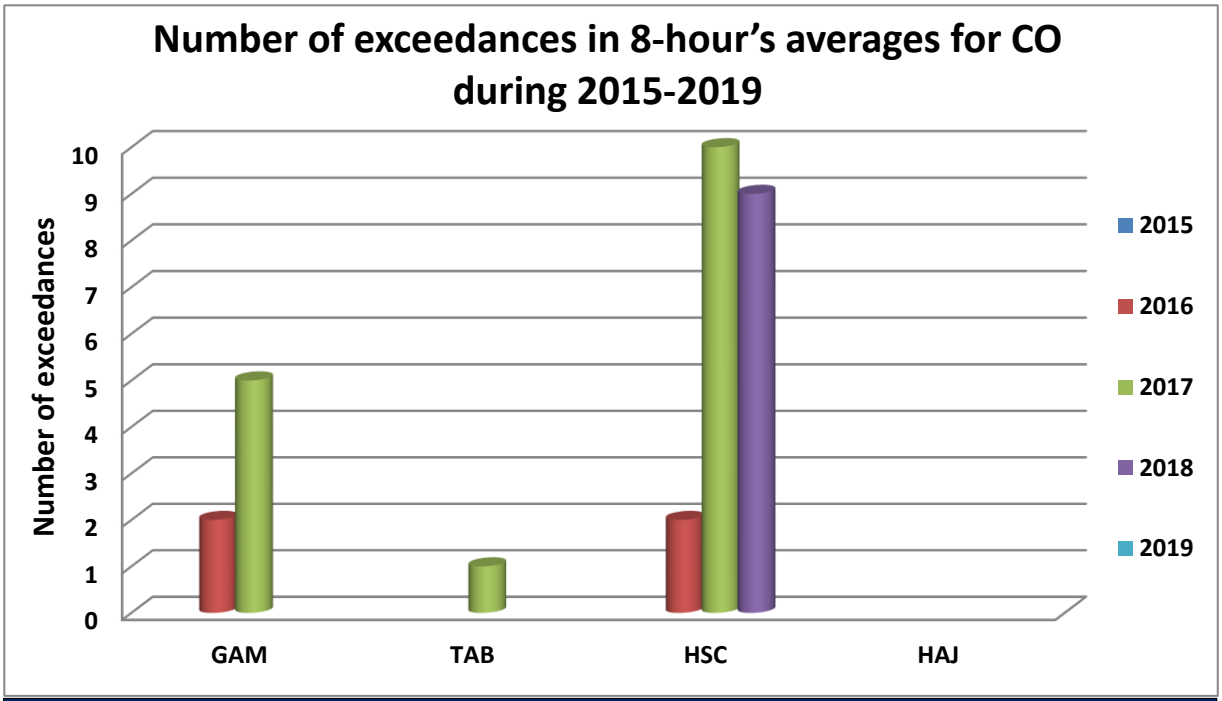


Figure (2.33): Number of exceedances in 8-hour's averages for CO during 2015-2019

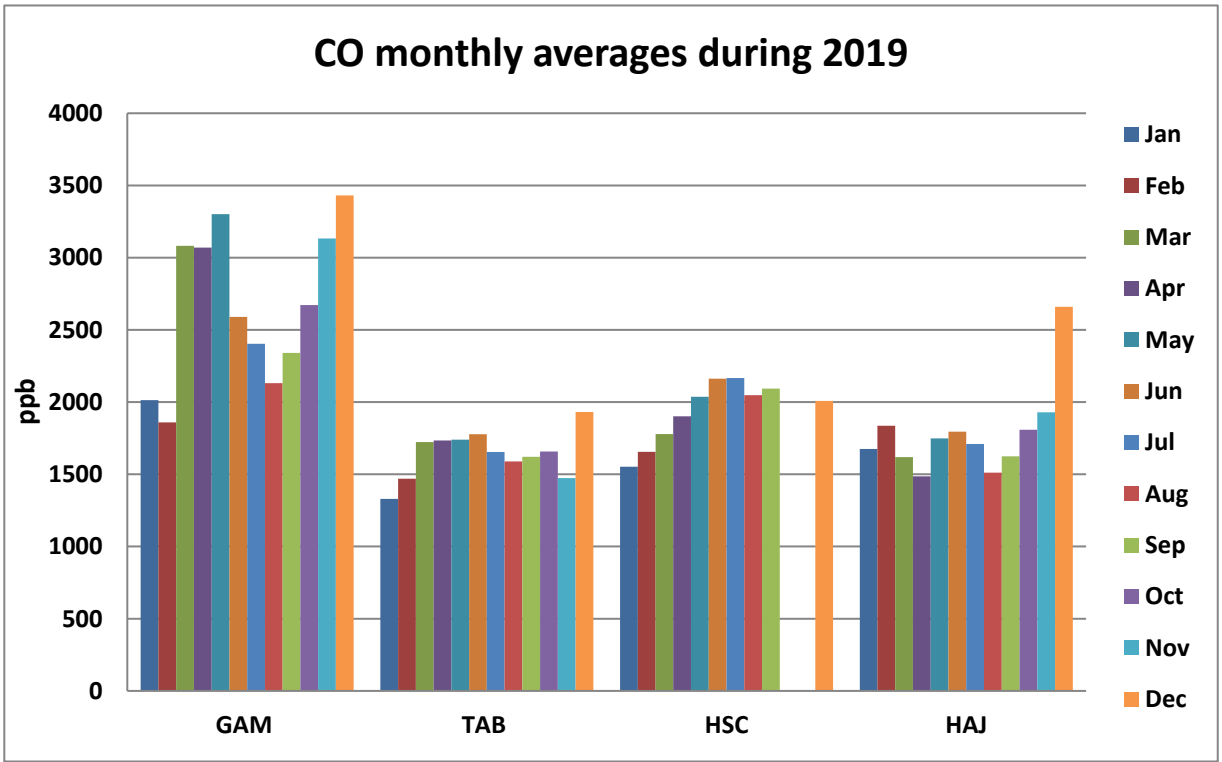


Figure (2.34): CO monthly averages during 2019

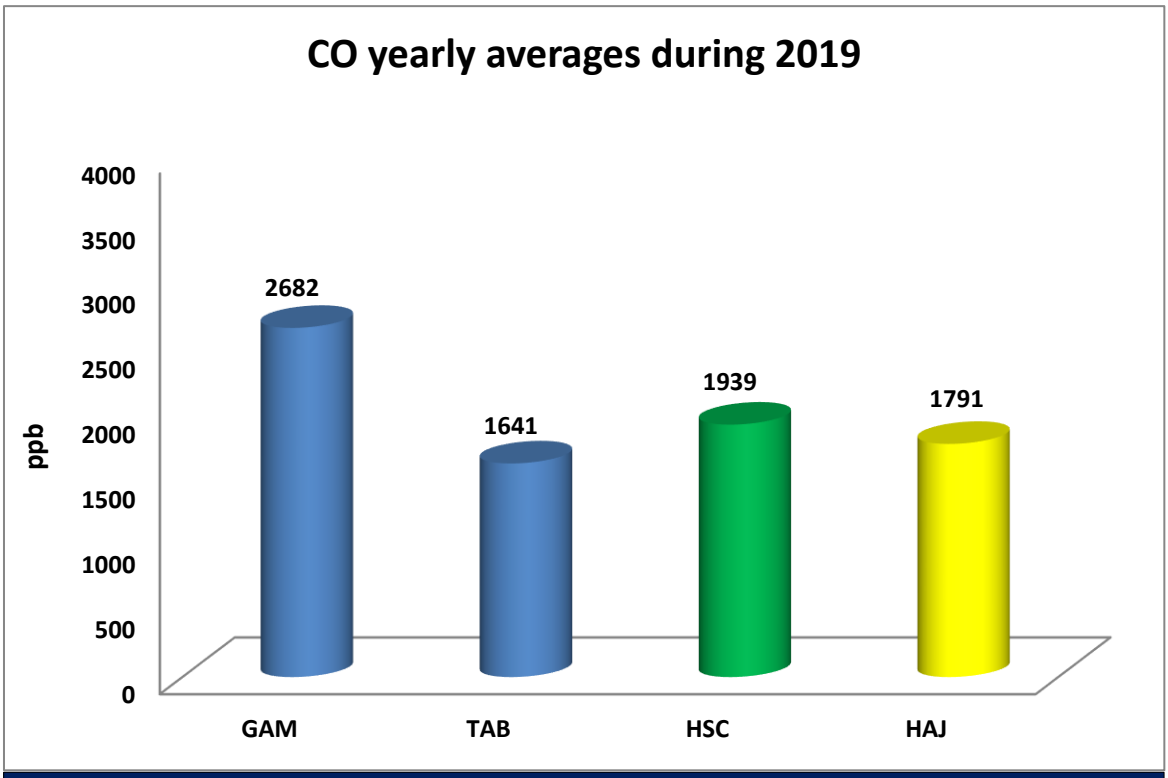


Figure (2.35): CO yearly averages during 2019

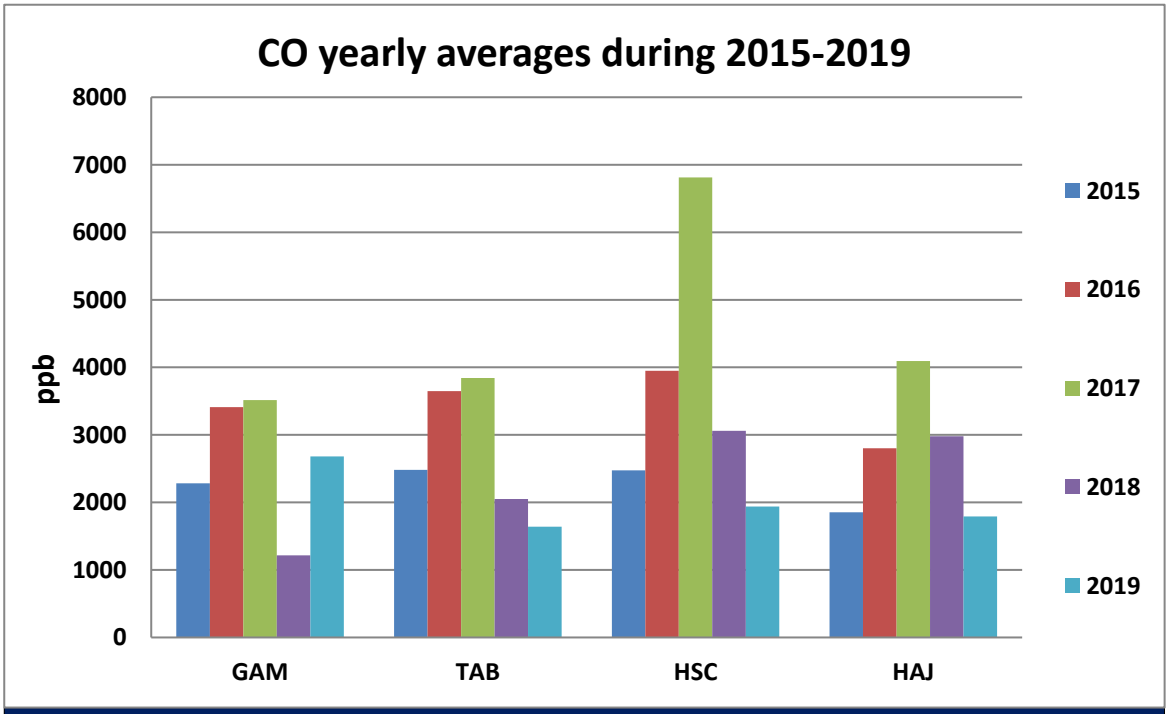


Figure (2.36): CO yearly averages during 2015-2019

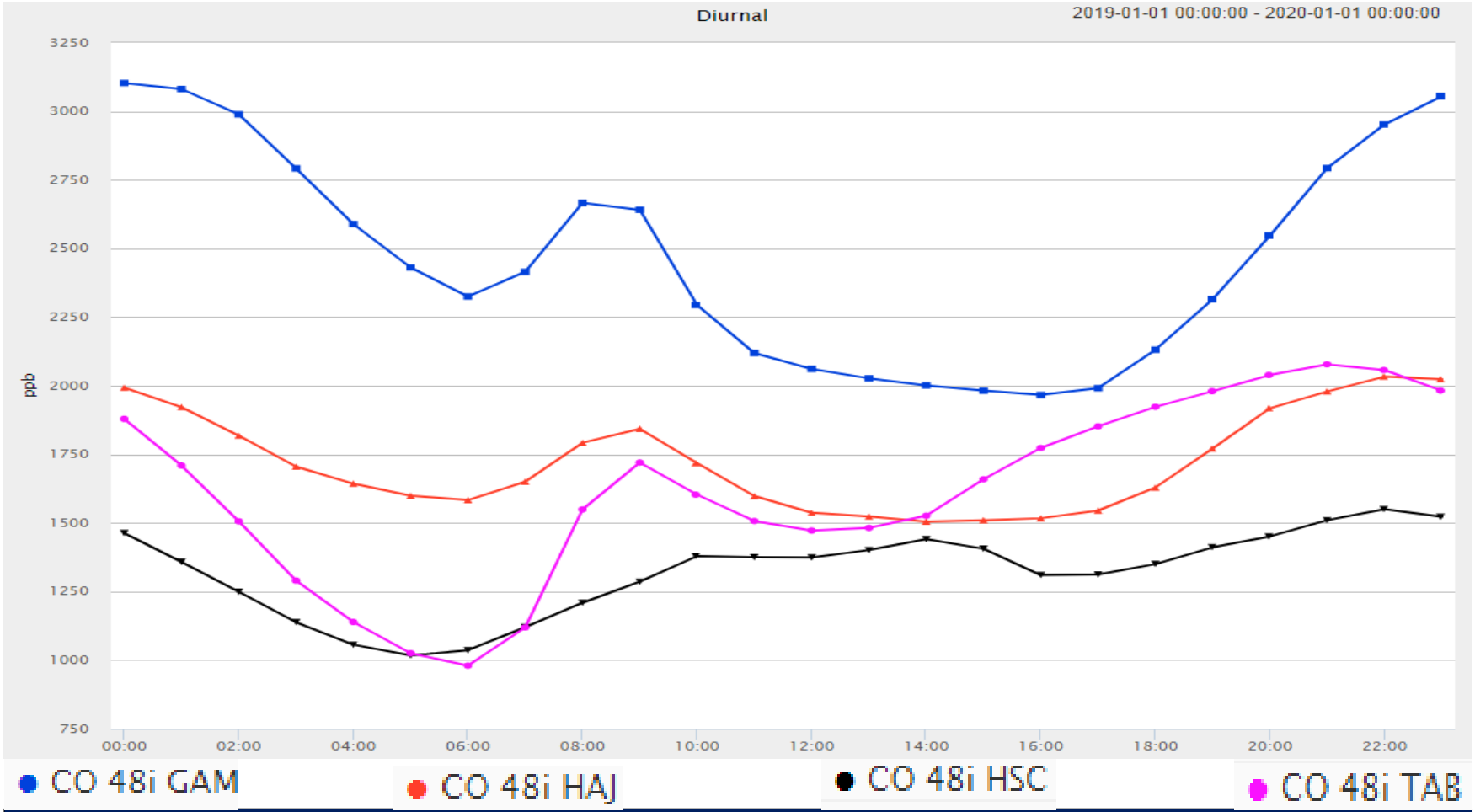


Figure (2.37): The average value in each hour of the day in all stations of Carbon monoxide (CO).

2.5 Ozone (O_3)

The ozone molecule consists of three oxygen atoms that are bounded together (triatomic oxygen, or O_3). Unlike the form of oxygen that is a major constituent of air (diatomic oxygen, or O_2), Ozone is a powerful oxidizing agent. Ozone reacts with biological membranes, such as those present in the linings of the human lungs and plant leaves, which can damage living cells. Exposure to Ozone has been associated with several adverse health effects, such as aggravation of asthma and decreased lung function.

The majority of tropospheric Ozone is formed when nitrogen dioxide (NO_2), carbon monoxide (CO) and volatile organic compounds (VOC_s), undergo photochemical reactions in air in the presence of sunlight. Thus NO_2, CO, and VOC_s are called Ozone precursors. Motor vehicle exhaust, industrial emissions, and chemical solvents are the major anthropogenic sources of ozone precursors. Although these precursors often originate in urban areas, winds can carry NO_2 hundreds of kilometers, causing ozone formation to occur in less populated regions as well.

The Jordanian Standard guidelines for Ozone are 120 ppb for 1-hour average concentrations and 80 ppb for 8-hour average concentrations and there is no yearly average guideline.

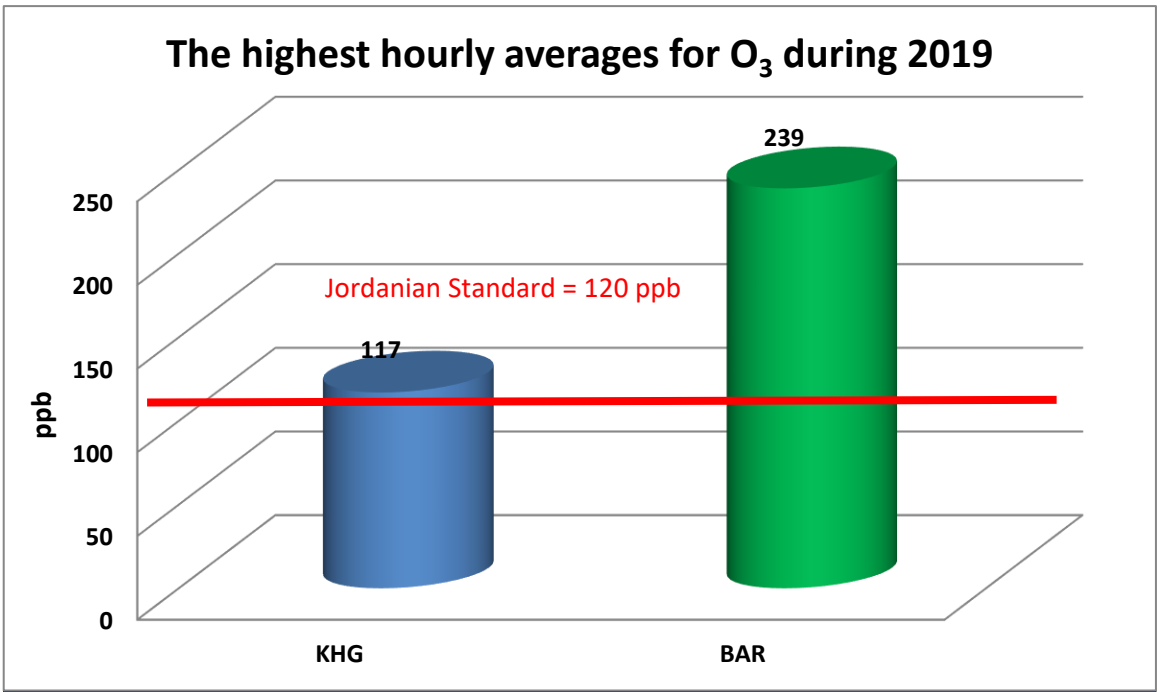


Figure (2.38): The highest hourly averages for O_3 during 2019.

The results of monitoring the ambient air quality showed that there was one exceedance in the hourly averages of O_3 gas than the allowable limit in the Jordanian standard (1140/2006) at Al Barha Street station in Irbid as shown in the figure (2.38).

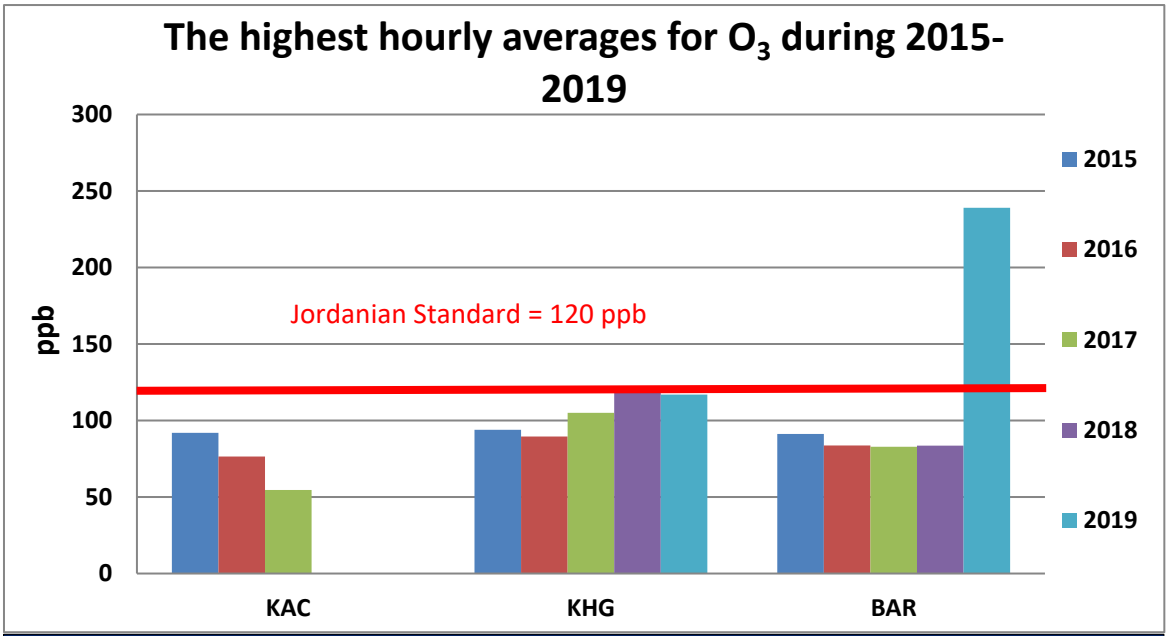


Figure (2.39): The highest hourly averages for O_3 during 2015-2019.

The ozone device was moved from Sahab station at the beginning of 2018

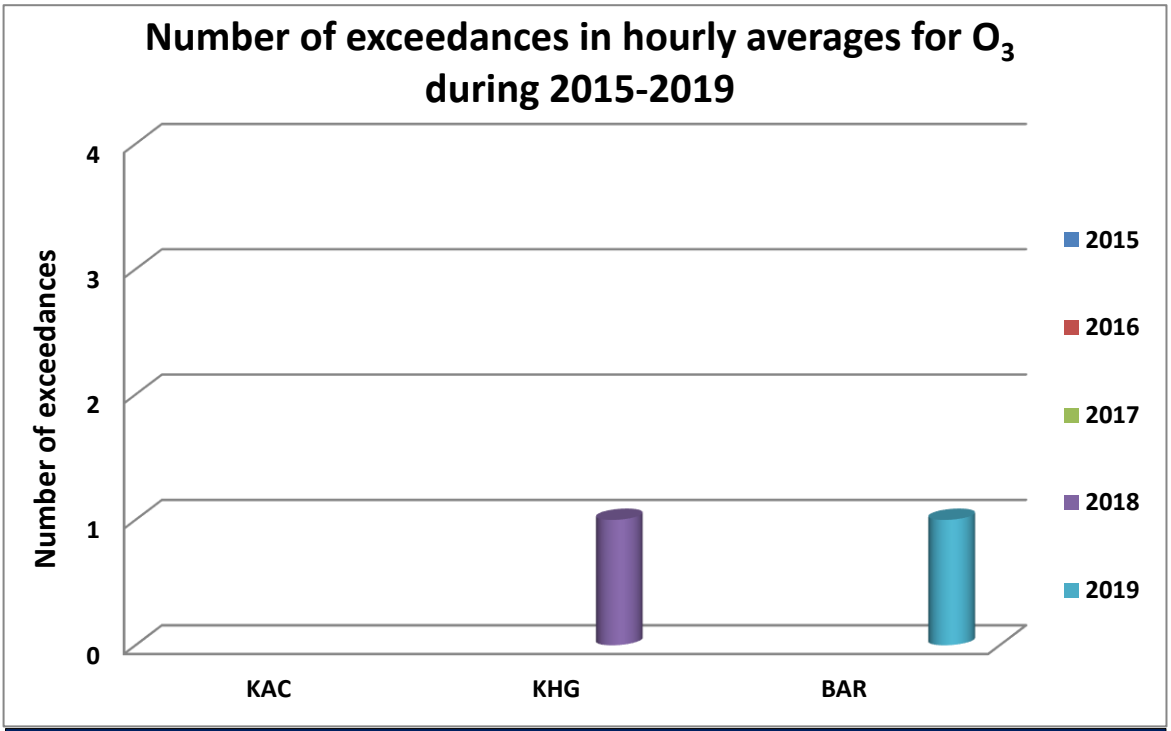


Figure (2.40): Number of exceedances in hourly averages for O_3 during 2015-2019

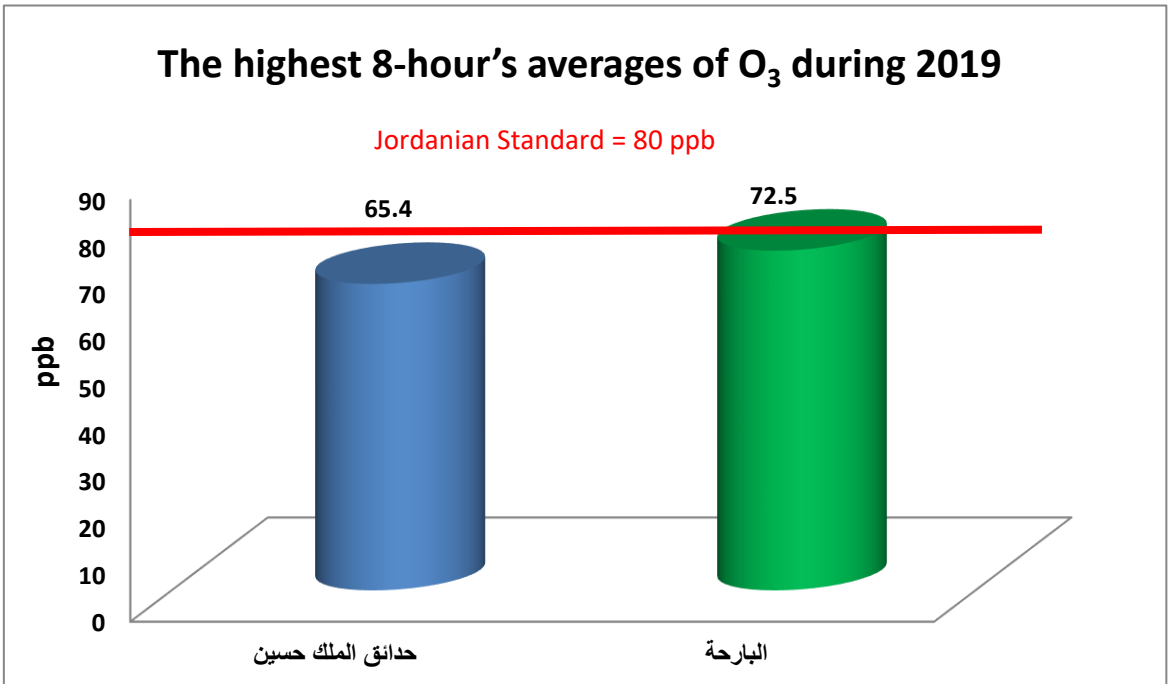


Figure (2.41): The highest 8-hour's averages of O_3 during 2019

The results of monitoring the ambient air quality showed that the daily averages of O_3 gas were within the limits allowed in the Jordanian standard (1140/2006) where no exceedances were monitored as shown in the figure (2.41), where the highest daily average of O_3 gas 72.5 ppb at Barha Street station in Irbid.

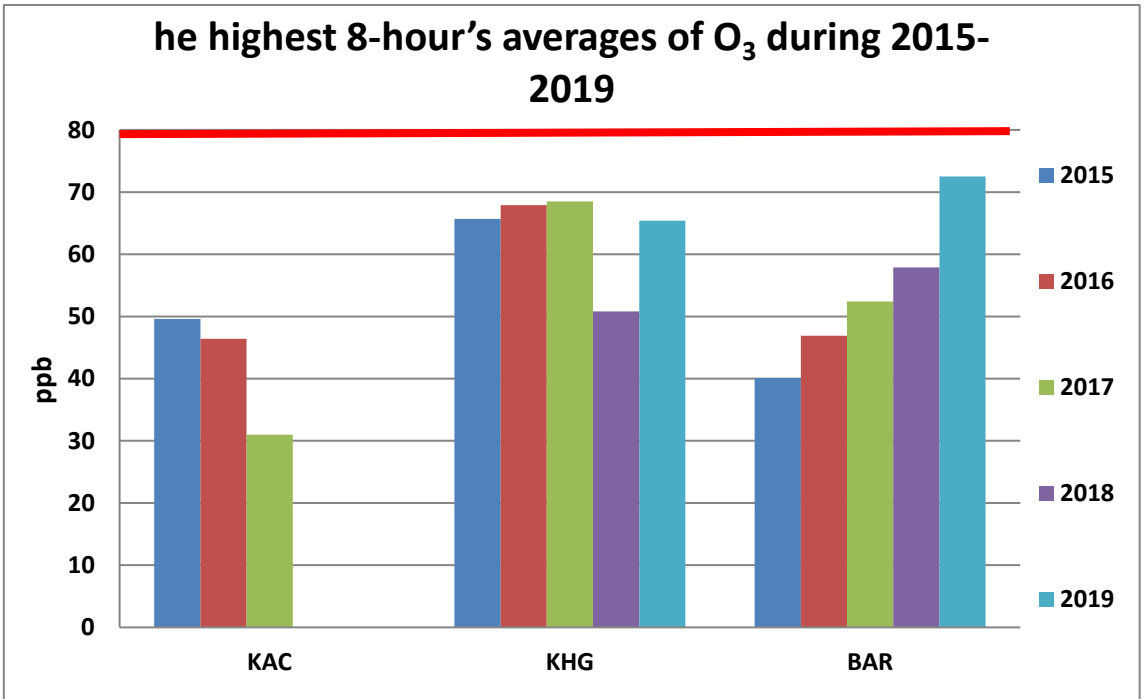


Figure (2.42): The highest 8-hour's averages of O_3 during 2015-2019

The ozone device was moved from Sahab station at the beginning of 2018

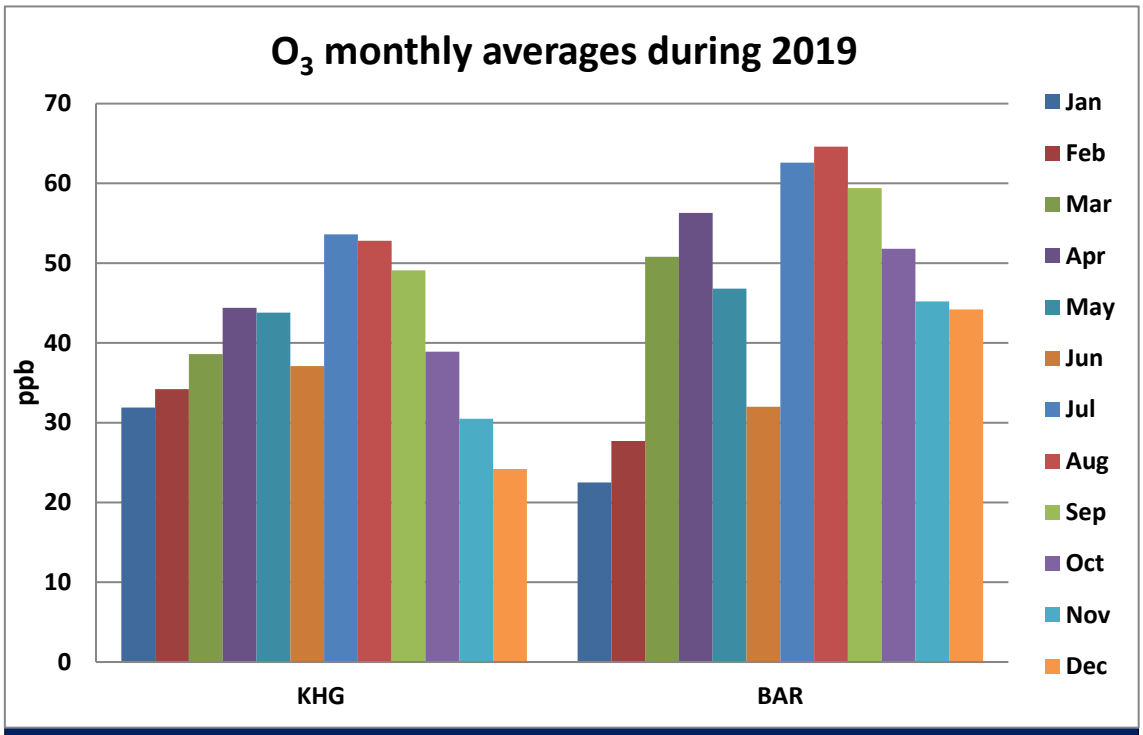


Figure (2.43): O_3 monthly averages during 2019.

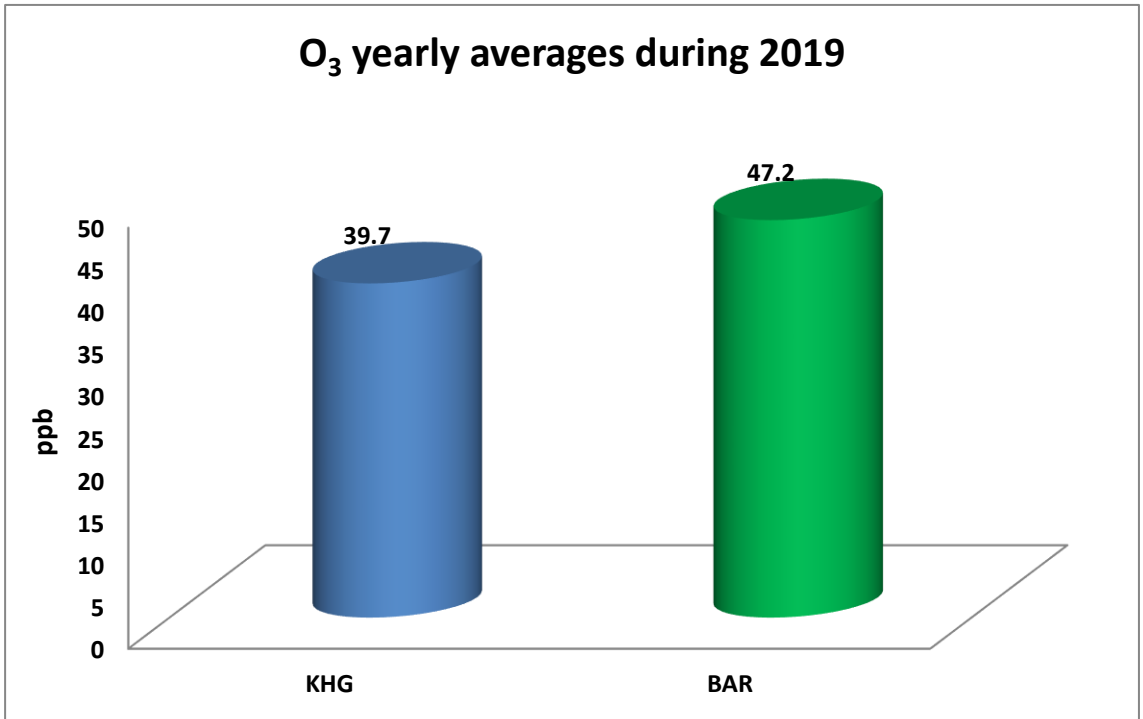


Figure (2.44):O_3 yearly averages during 2019

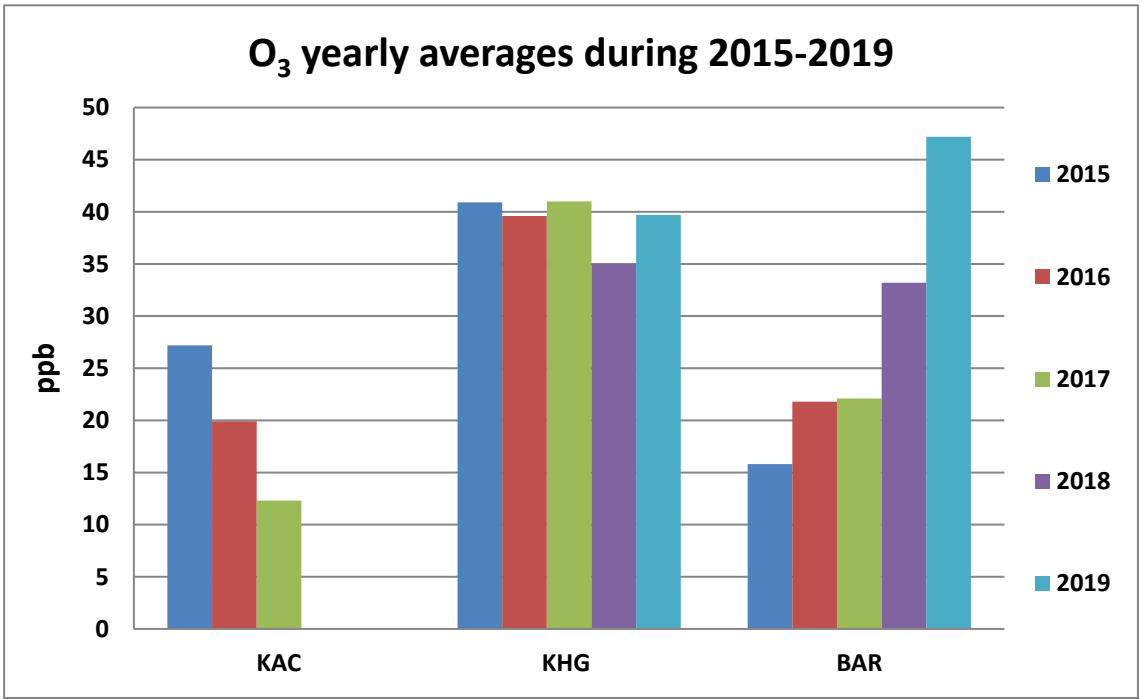


Figure (2.45):O_3 yearly averages during 2015-2019

The ozone device was moved from Sahab station at the beginning of 2018

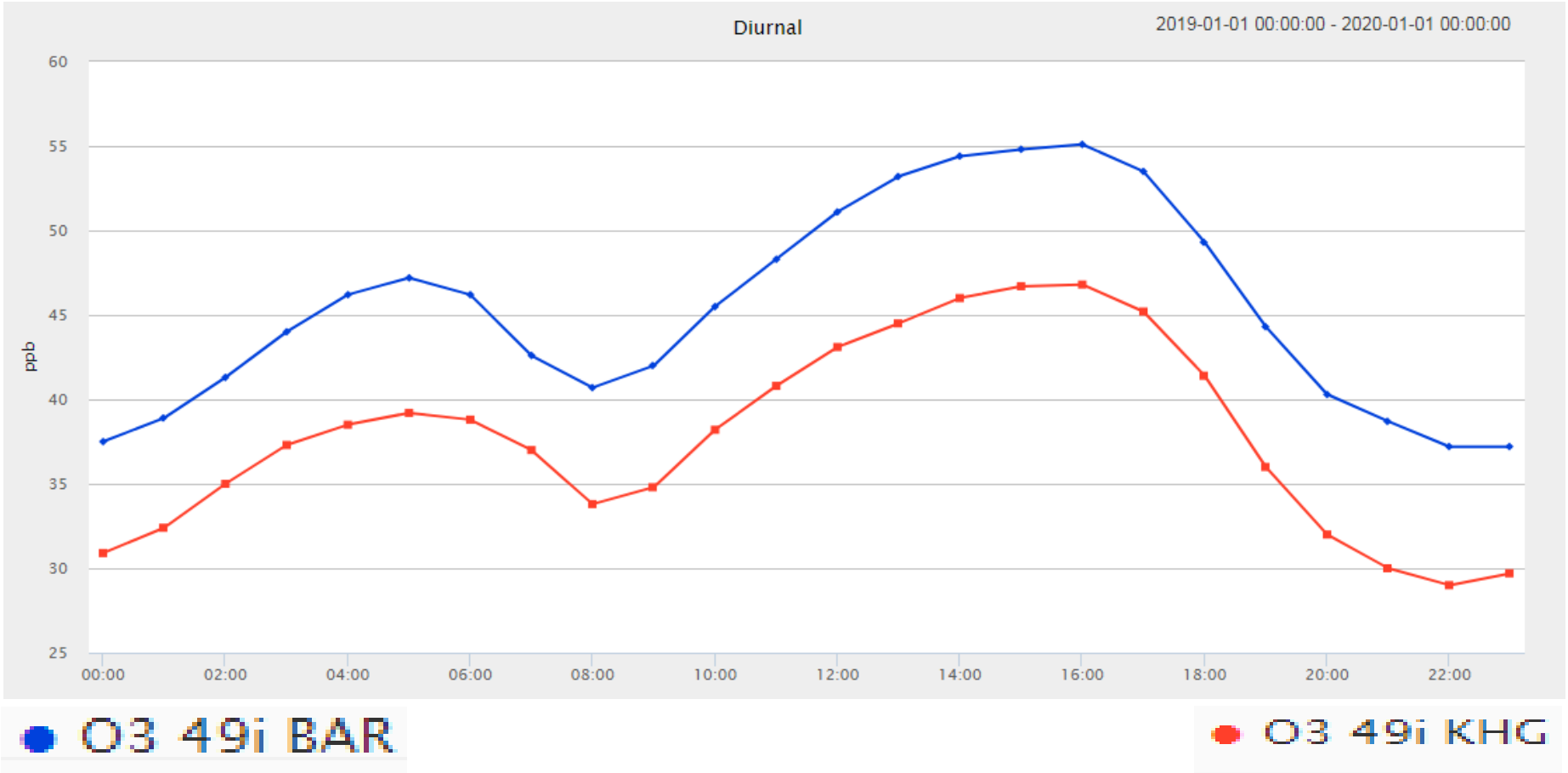


Figure (2.46): The average value in each hour of the day in all stations of Ozone (O_3)

2.6 Meteorology: Wind Speed and Direction, Temperature and Humidity

King Hussein Gardens (Amman)

- As shown in figure (2.47), wind direction at the King Hussein Gardens (Reference station) in Amman is mainly from south – west, where the annual average wind direction was 235◦. Wind direction at the Barha street station in Irbid figure (2.48) is almost south-east, where the average wind direction is 140◦. And in Zarqa – Wadi Al-Hajjar station figure (2.49) the wind is mainly from the south – west, where the direction of the wind is 169◦.

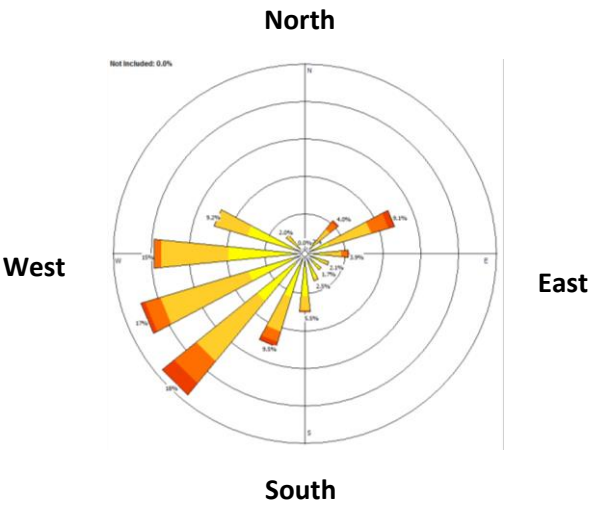
Temperature

- Minimum daily temperature: 1.14 °C
- Maximum daily temperature: 28.6 °C
- Minimum hourly temperature: -1.71 °C
- Maximum hourly temperature: 34.9 °C
- Average yearly temperature: 15.1 °C

Humidity

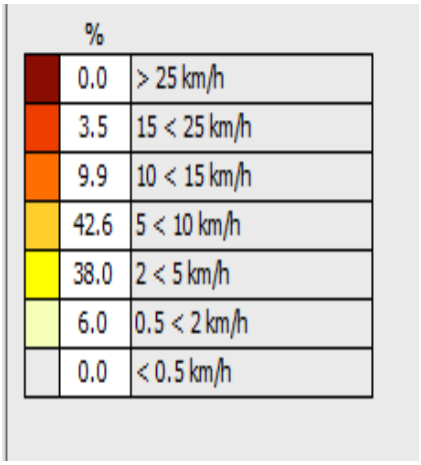
- Minimum daily humidity: 21.6 %
- Maximum daily humidity: 100 %
- Minimum hourly humidity: 18 %
- Maximum hourly humidity: 100 %
- Average yearly humidity: 65.3 %

Wind Direction



Average: 235 °

Wind Speed



Average: 6.16 km/h

Figure (2.47): Meteorological data for King Hussein Gardens Station (Amman)

Al Barha Street (Irbid)

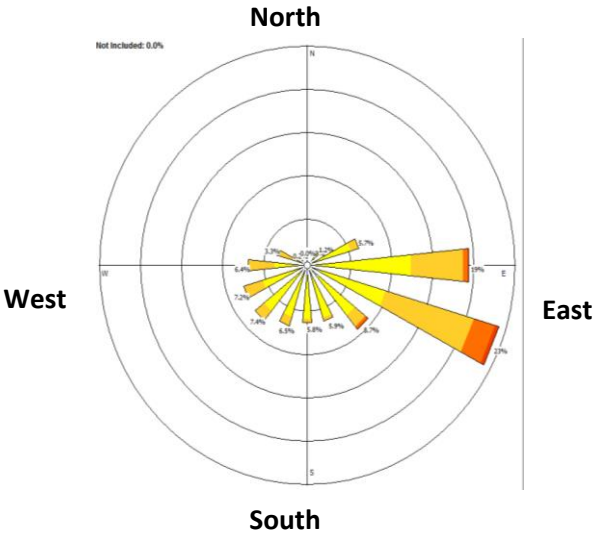
Temperature

- Minimum daily temperature: 6.6 °C
- Maximum daily temperature: 33.3 °C
- Minimum hourly temperature: 2.48 °C
- Maximum hourly temperature: 41.1 °C
- Average yearly temperature: 19.3 °C

Humidity

- Minimum daily humidity: 13.7 %
- Maximum daily humidity: 90.3 %
- Minimum hourly humidity: 9 %
- Maximum hourly humidity: 95 %
- Average yearly humidity: 56.1 %

Wind Direction



Average: 140 °

Wind Speed

%	
0.0	> 25 km/h
0.6	15 < 25 km/h
3.6	10 < 15 km/h
31.5	5 < 10 km/h
59.5	2 < 5 km/h
4.8	0.5 < 2 km/h
0.0	< 0.5 km/h

Average: 4.7 km/h

Figure (2.48): Meteorological data for Al-Barha Street Station (Irbid)

Wadi Al-Hajjar (Zarqa)

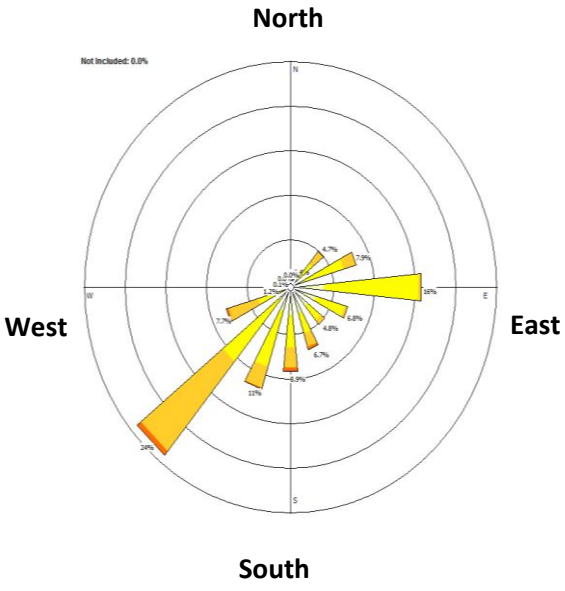
Temperature

- Minimum daily temperature: 8.8 °C
- Maximum daily temperature: 34.5 °C
- Minimum hourly temperature: 3.9 °C
- Maximum hourly temperature: 43.3 °C
- Average yearly temperature: 18.5 °C

Humidity

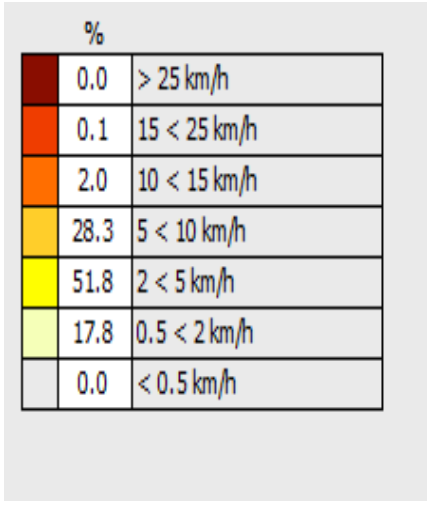
- Minimum daily humidity: 16 %
- Maximum daily humidity: 90.3 %
- Minimum hourly humidity: 6 %
- Maximum hourly humidity: 100 %
- Average yearly humidity: 53.9 %

Wind Direction



Average: 169 °

Wind Speed



Average: 4.1 km/h

Figure (2.49): Meteorological data for Wadi Al-Hajjar Station (Zarqa')

3

CONCLUSION

- Air pollution measurement results indicate that the ambient air quality in Amman, Irbid, and Zarqa' is good for most days of the year based on the Jordanian technical standard for ambient air quality 1140/2006 (Table 1.2).

- Pollutants (Carbon monoxide (CO), Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2) and Ozone (O_3) at most stations were within the limits of the Jordanian technical standard for ambient air No. 1140/2006.

- Intermittent and seasonal sandstorms contributed to raising the concentrations of particulate matters with an effective diameter less than or equal to ≤ 10 microns (PM10), leading to exceedances in most locations for daily averages in addition to monitoring one exceedance in the annual average of PM10 in Mahatta station/Amman.

- The wind direction in Amman during the measurement period was southwest, with an average speed equal to 6.16 km/h, and in Zarqa the wind direction was southwest with an average speed of 4.1 km/h, and in Irbid the wind direction was southeast with an average speed of 4.7 km/h.

- The results of monitoring the live broadcasting site of the ambient air quality index (AQI) launched by the Jordanian Ministry of Environment showed that the air quality index in 12 monitoring stations in the Kingdom ranged between green (good) and yellow (moderate), and changed to dark colors at times, especially during sandstorms or due to heavy traffic.

4

RECCOMMENDATIONS

1) Continue to monitor the ambient air quality in the current monitoring sites, and increase the number of stations to cover all areas in the kingdom not covered by continuous monitoring and include them in the national monitoring network database.

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2) The necessity of developing a national and sectoral strategy to combat air pollution and implement air pollution mitigation plans.

3) Add devices to measure PM2.5 in line with WHO recommendations due to their harmful health effects.

4) Adding continuous analyzers to measure black carbon concentrations in areas that suffer from heavy traffic.

5) Add measurement analyzers to the existing twelve AQ stations to cover other criteria pollutants as required since currently not all pollutants are measured in all stations.

6) Measurement of meteorological elements, wind speed and direction in all stations as they are monitored in only three stations.

7) Review and update Jordanian legislation and standards related to air quality.