Ambient Air Quality Measurement in Al-Asmarat Discrete, Al-Muqatam, Cairo, Egypt, A Case study.

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The ambient air pollution of Al-Asmarat discrete, Al-Muqatam, Cairo, Egypt was measured on a 24 hours basis at one sampling station during the summer of 2018 by collecting samples of carbon monoxide (CO), sulfur dioxides (SO_2), hydrogen sulfide (H_2S), nitrogen oxides (NO_2), ozone (O_3) and particulate matters PM (2.5&10) at 15/16 July 2018 and 2/3 August 2018. Temperature and humidity were also measured. Major contributors to those pollutants were due to mobile vehicles and open burning emissions of Al Wafaawa Al Amal dump. We found that the mean concentrations of the air pollutants at the first measurement 15/7 for CO, SO_2, H_2S, NO_2, O_3 and PM (10&2.5) were 0.928 mg/m^3, 42.86 µg/m^3, 151 µg/m^3,69.8 µg/m^3, 21.4 µg/m^3, and (52.35& 62.71 µg/m^3), respectively. While the concentration at the second measurement 2/8 were1.10 mg/m^3, 196.1µg/m^3, 252µg/m^3, 21.2µg/m^3 and (39.9&46.7µg/m^3), respectively. In conclusion, air pollutant concentrations in Al-Asmarat are lower except for SO_2 and H_2S. The mean H_2S concentration was 40 times the World Health Organization (WHO) cut-off limits and the mean SO_2 concentration was more than WHO guidelines and the Egyptian law No.4, while NO_2, NO, O_3 and PM (10&2.5) concentrations are below WHO guidelines and the Egyptian law No.4. Long-term studies are needed to characterize air pollution levels during all seasons, to assess related public health impacts, and explore mitigation approaches.

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The National Review of Criminal Sciences, Volume 62, No.1, March 2019.

1- Introduction

Air pollution is an important determinant of health. A wide range of adverse effects of ambient air pollution on health has been well documented by studies conducted in various parts of the world[(1)]. There is significant inequality in exposure to air pollution and related health risks: air pollution combines with other aspects of the social and physical environment to create a disproportionate disease burden in less affluent parts of society[(2,3)]. Air pollution is associated with a range of diseases, symptoms and infra clinic conditions that impair the health and quality of life. In the recent years, several epidemiological studies have reported associations between an increase in daily levels of ozone (O_3) and particulate matter (PM), and an increase in the following days, of the mortality and hospital admissions predominantly related to respiratory and cardiovascular diseases[(4)]. These short-term effects have been extensively documented in multicentre time-series studies[(5-7)]. Ambient air is the air outside of buildings to which the public has access. Ambient standards protect the public from adverse health and welfare effects associated with air pollutants. Standards exist for particulate matter, ozone, carbon monoxide, nitrogen dioxide, and sulfur dioxide. The World Health Organization (WHO) and the US Environmental Protection Agency (USEPA) have defined guideline limits for these pollutants that should not be exceeded in order to maintain and protect public health [(8-12)]. The WHO limits for PM2.5, PM10, NO_2, SO_2, and O_3 are 25 $\mu g/m^3$ (24-hour mean), 50 $\mu g/m^3$ (24-hour mean), 200 $\mu g/m^3$ (one-hour mean), 20 $\mu g/m^3$ (24-hour mean), and 100µg/m3 (eight-hour mean), respectively[(8)], while the limits for the same pollutants set by the USEPA are PM 2.5 35 $\mu g/m^3$ (24-hour mean), PM10 150 $\mu g/m^3$ (24-hour mean), NO_2 100 ppb or 200 $\mu g/m^3$ (one-hour mean), SO_2 75 ppb or 150 $\mu g/m^3$ (one-hour mean) and O_3 0.075 ppm or 150 $\mu g/m^3$ (one-hour mean) [(9)], Table [1]. The WHO also reviewed information on health effects and recommended a daily (24-hour) value of 0.1 ppm H_2S. This value was based on the eye irritation effects at 10 ppm and a safety factor of 100[(10)].

While USEPA acute guideline 30 ppb (42µg/m^3) recommended for use with 1- hour averaging time and 2µg/m^3as acute guideline for use with 1 year[11,12].

In Egypt, Humans and the environment are exposed to a complex mixture of many air pollutants emitted from various sources and subject to atmospheric processes that can create new pollutants. Many of these pollutants can cause severe health problems and impact on ecosystems[13,14]. Emissions of air pollutants derive from almost all economic and societal activities, road transport, industry, power plants, households, and agricultural activities continue to emit significant amounts of air pollutants [15, 16]. Combustion of biomass and solid fuels by households is an important source of directly emitted particulate matter (PM), O_3, NO_2, SO_2, CO, volatile organic compounds (VOC) and polycyclic aromatic hydrocarbons (PAHs)[17]. The current study assesses air pollution and provides a data on ambient concentrations of six key air pollutants (CO, SO_2, H_2S, NO_2, O_3 and PM (10&2.5)).

1.1. Notes on air pollutants

1.1.1. Carbon oxide (CO)

The highest ambient Carbon oxide (CO) concentrations are found near traffic in cities, road traffic, and at many locations in urban areas. CO readily reacts with hemoglobin in the human blood forming carboxyhemoglobin (COHb) and as a result this binding reduces the oxygen-carrying capacity of the blood and impairs the release of oxygen to extra vascular tissues. So, the WHO adopted in 1999 four guidelines for the maximum CO concentrations, 100 mg/m^3 for 15 minutes, 60 mg/m^3 for 30 minutes, 30 mg/m^3 for 1 hour and 10 mg/m^3 for 8 hours[18].

1.1.2. SO_2

Sulfur Dioxide (SO_2) is one of a group of gases called sulfur oxides (SO_2). The other gases in the group are much less common in the atmosphere. SO_2 is the component of greatest concern and is used as the indicator for the larger group of gaseous sulfur oxides (SO_2)[13]. Other gaseous SO_2 (such as SO_3) are found in the atmosphere at concentrations much lower than SO_2. Emissions that lead to high concentrations of SO_2 generally also lead to the formation of other SO_2. The largest sources of SO_2 emissions are from fossil fuel combustion at power plants and other industrial facilities. Short-term exposures to SO_2 can harm the human respiratory system and make breathing difficult. Children, the elderly, and those who suffer from asthma are particularly sensitive to effects of SO_2[9,19].

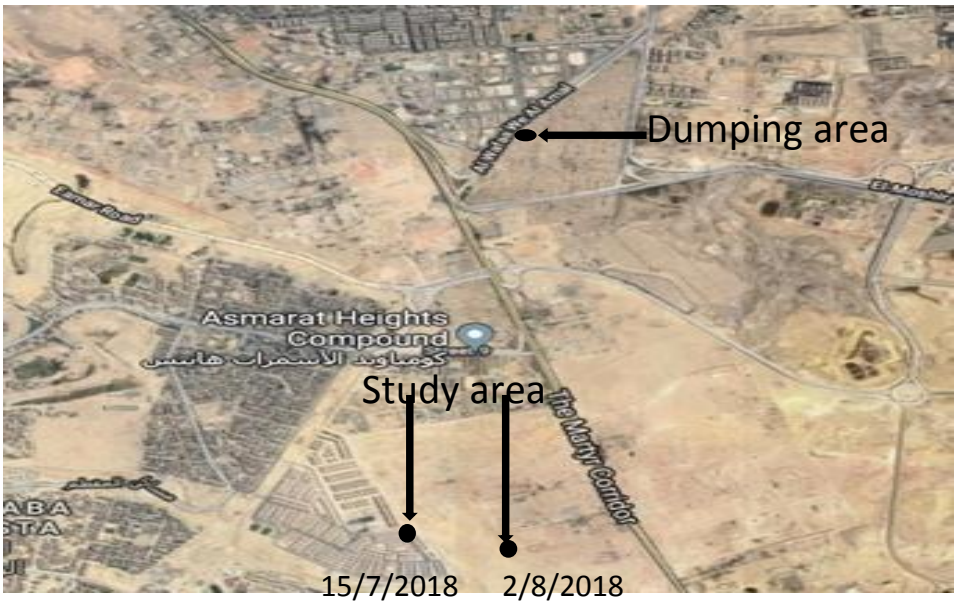

Fig. (1)*:* Sampling location for the ambient air samples collected from residential area at Al Asmarat discrete

1.1.3. Hydrogen sulfide (H_2S)

Hydrogen sulfide (H_2S) is a colorless gas, soluble in various liquids including water and alcohol. It can be formed under conditions of deficient oxygen, in the presence of organic material and sulfate. Most of the atmospheric hydrogen sulfide has natural origins. Hydrogen sulfide occurs around sulfur springs and lakes and is an air contaminant in geothermally active areas [(8)]. In north-west London, over a period of 2.5 years, air levels of hydrogen sulfide were generally below 0.15µg/m^3under clear conditions [(8)]. In its acute form, hydrogen sulfide intoxication is mainly the result of action on the nervous system [(11,21)]. At concentrations of 15µg/m^3 and above, hydrogen sulfide causes conjunctival irritation, because sulfide anion and hydrogen sulfide are strong acids [(20)]. WHO recommends that in order to avoid substantial

complaints about odors annoyance, 30 minutes average hydrogen sulfide concentrations should not exceed 7 μg/m^3 [8], Table [2].

1.1.4. Nitrogen oxides (NO_2)

Nitrogen oxides (NO_2), principally nitric oxide (NO) and nitrogen dioxide (NO_2), are formed both by oxidation of nitrogen compounds present in fuel and by high temperature oxidation of the molecular nitrogen that is the main constituent of air. As a consequence, combustion of all fuels, even fuels with no nitrogen component, can yield NO_2. Nitrogen oxides contribute to the formation of tropospheric ozone and nitrate aerosols. NO_2 is emitted during fuel combustion, such as by vehicle engines, industrial facilities and domestic heating. Among the chemical species that comprise NO_x, NO_2 is associated with adverse effects on health, as high concentrations cause inflammation of the airways and reduced lung function [22]. NO_2 may also cause adverse effects on vegetation and contributes to the formation of secondary inorganic PM and O_3 with associated effects on health, ecosystems and climate [23].

1.1.5. Ozone (O_3)

Ozone is formed in the atmosphere by photochemical reactions in the presence of sunlight and precursor pollutants, such as the oxides of nitrogen (NOx) and volatile organic compounds (VOCs)[24]. It is destroyed by reactions with NO_2 and is deposited to the ground. Several studies have shown that ozone concentrations correlate with various other toxic photochemical oxidants arising from similar sources, including the peroxyacyl nitrates, nitric acid and hydrogen peroxide [25]. Measures to control tropospheric ozone levels focus its precursor gas emissions but are likely to also control the levels and impacts of a number of these other pollutants. At 8-hour concentrations exceeding 240 μg/m^3, ozone causes significant reductions in lung function, as well as airway inflammation that would cause symptoms and alter performance [26].

1.1.6. Particulate matters PM (10&2.5)

In terms of potential to harm human health, PM poses the greatest risk, as it penetrates to sensitive regions of the respiratory system and can lead to health problems and premature mortality [25]. PM in the air has many sources and is a complex heterogeneous mixture. The sizes and chemical composition of this mixture can change in time and space, depending on emission sources and atmospheric and weather conditions. PM in the atmosphere originates from primary particles emitted directly and secondary particles produced as a result of chemical reactions involving PM forming (precursor) gases: SO_2, NO_x, $NH_3$and non-methane volatile organic compounds (NMVOC)[25]. The EPA integrated science assessment for PM concluded that, in general, short-term epidemiological studies reported positive associations between mortality and cardiovascular and respiratory hospital admissions[8-10].

2. Study period and study areas

The study was performed at Al Asmarat discrete, AlMuqatam, Cairo governorate, Egypt. Al Asmarat discrete is considered as one of the new residential neighborhoods built under the guidance of the government, housing to accommodate slum dwellers in Cairo. The project includes 18,300 housing units that will be built on three stages of time. A total of 10,614 families have been accommodated until the date of study, Fig. [1]. The problem of the Al-Asmarat neighborhood in general is that it located in a low area of the dump of Al-Wafaa Wa Alamal which is specially designed to burn, at night, wastes in all its forms which affects the quality of ambient air surrounding this populated area. Al-Asmarat neighborhood is located about 5 km away from Al-Wafa Wa Alamal and in a very low area for the burning area and in the direction of the wind, which makes the residents of the area affected by the gases emitted from the dump. The study period, 15-16 July 2018 and 2-3 August 2018 was chosen arbitrarily. The study points were defined according to the advice of local experts in order to ensure that average pollutant levels measured at fixed

monitors could be considered good indication of the ambient air pollution.

3. Emission data guidelines

Air pollutant emissions data of carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NOx), ozone (O_3), and PM (2.5&10)were downloaded from the Egyptian environmental law No. 4 for 1994 for environment protection and its amendments by law No. 9 for 2009 and its executive regulation board issued in 2011 and 2012 Table [1], while H_2S were downloaded from WHO guidelines [8,10] and National ambient air quality standards (NAAQS)[12].

4. Methodology [22]

4.1. Equipment used in the present Measurements

The equipment used were Thermo Environmental Instruments Incorporation. MODELS: 42C Chemiluminescence for NOx, 43C Pulsed Fluorescence Analyzer for SO_2, 48C U.V Photometric Analyzer for CO, 49i Ozone Analyzer Multigas Calibration System for O_3, Air metrics Mini Vol. portable low volume sampler for PM (10&2.5). Thermo Environmental Instruments Incorporation. MODEL 111 was used for Producing Zero Air for H_2S. Data will be given as 10 min Average for continues monitoring of all samples.

4.1.1. Carbon monoxide (CO)

Carbon monoxide monitor, model Thermo, was used for measuring the carbon monoxide concentration in ambient air. CO analyzer used in the present project was a non –dispersive infrared photometer that uses gas filter correlation technology to measure low concentrations of CO accurately and reliable by use of state-of-the art optical and electronic technology. When environmental conditions change, the instrument automatically zeros itself by drawing in air, which passed through a catalyst to remove CO, and stores the information in the memory of a microprocessor. All readings are corrected before output. Display,

graphics, printouts and RS232 outputs are auto ranging. All the previous measurements were performed for eight hours as five minutes average values. 60 minutes average values were calculated.

4.1.2. Sulfur dioxide (SO_2)

One sulfur dioxide monitor (model Thermo) was used for measuring the concentration of SO_2 in ambient air down wind. The measurement based on measurement of the fluorescent signal generated by exciting SO_2 with UV light. The internal zero span self- check option includes a temperature control permeation tube, TFE zero span valves and zero air scrubber. The zero check and calibration can be performed remotely from contact through a RS232 command. The computer operating system continuously monitors all critical operating points of the instrument to confirm proper operations.

4.1.3. Nitrogen oxides(NO and NO_2)

Thermo-monitor for Nitrogen oxides (NO-NO_2-NOx) was used in the present project. The principal of chemilumiscent reactions between NO and O_3 was used for measuring NO_x, NO and total NO_x are being measured. NO_2 is estimated after reduction of NO_2 by catalytic converter. NO_2 measurements can be made even in areas with rapidly changing NO concentrations.A multi-tasking computer operating system continuously monitors all critical operating points in the instrument to confirm proper operations.

4.1.4. Ozone Analyzer:

The Thermo Scientific Model 49i analyzer is a dual cell photometer, the concept adopted by the NIST for the national ozone standard. Dual range and auto range are standard features of the Model 49i analyzer. Because the instrument has both sample and reference flowing at the same time, a response time of 20 seconds can beachieved. Temperature and pressure correction are standard offerings. User settable alarm levels for

concentration and for a wide variety of internal diagnostics are available from an easy to follow menu.

4.1.5. Respirable Particulate Matter (PM2.5&10)**.**

Affordable and portable, the Mini Vol. Portable Air Sampler samples ambient air at 5 liters/minute for particulate matter (PM2.5&10). The Mini Vol. features an elapsed time totalizer, a programmable timer ,low flow and low battery shut-offs ,operation from rechargeable batteries ,and rugged PVC construction .The filter holder assembly can be configured for either PM10or PM2.5 sampling ,and a Mini Vol. with gas ability can sample for non-reactive gases simultaneously while sampling for particulate matter. Particle size separation is achieved through impaction. The particulate matter is collected on 47 mm filters, which must be weighed pre-and post-exposure to determine concentration in micrograms/cubic meter. The patented low- flow technology found in the Mini Vol. sampler was jointly developed by the US EPA and Air metrics. EPA owns nearly 200 Mini Vol., which are housed in east and west coast repositories and are available for use by local air authorities and Native American Indian tribes. PM2.5&10 were measured in ambient air by using Air metric for 24hrs.Preweighed filters were used for collecting the particulate matter over eight hours then subjected for Gravimetric analysis on calibrated six digits balance.

5- Results and Discussion

By comparing the data obtained from the first measurement on 25/7 and the second one on 2/8 we found that there was no significant difference between the concentrations of all studied ambient air pollutants except sulfur dioxide (SO_2) and hydrogen sulfide (H_2S) Table [3,4]. Our finding of ambient air pollutant concentrations was below WHO guideline levels, NAAQS of USEPA and the Egyptian law No.4 except for sulfur dioxide (SO_2) and hydrogen sulfide (H_2S). The minimum and maximum concentrations of carbon monoxide (CO) on 15/7 were 0.551 mg/m^3(12.30 pm) and 1.6 mg/m^3 (9.00 pm), respectively with average 9.28 % and on 2/8were 0.598 mg/m^3 (3.00 am) and 1.51mg/m^3 (8.00 am) with average 11.02%, respectively. The increased concentration of carbon monoxide (CO) on 2/8 may due to the possibility of some vehicles in the same place and during the measurement period. Table (2,3) show for sulfur dioxide (SO_2), on 15/7 the minimum and maximum concentrations were 3$\mu g/m^3$ (4.00 pm) and 119$\mu g/m^3$ (1.30 pm), respectively with average 34.29 %and on 2/8 were11.9$\mu g/m^3$ (10.00 pm) and 519 $\mu g/m^3$ (8.30 am), respectively with average156 %.The noticeable high concentration of SO_2 may be attributed to the combustion of dumps containing sulfur materials. This concentration was higher than WHO guidelines, NAAQS and the Egyptian law No.4 cut-off, Table [1, 2]. In this study, the data also revealed that hydrogen sulfide (H_2S) concentrations were very high, compared to the WHO guideline levels, NAAAQS and the Egyptian law where the min. and max. concentrations on 15/7 were 59 $\mu g/m^3$ (8.30 am) and 270 $\mu g/m^3$(9.00 pm), respectively. On the other hand, on 2/8, the minimum and maximum concentrations were 155 $\mu g/m^3$ (8.30 am) and 334 $\mu g/m^3$ (9.30 pm), respectively while WHO cut- off and NAAQS for H_2S is 7$\mu g/m^3$and 42$\mu g/m^3$with a 30-minutes averaging period, respectively. The minimum and maximum concentrations of nitrogen dioxide (NO_2) on 15/7 were 7$\mu g/m^3$(9.30 am) and 142 $\mu g/m^3$(2.30 pm), respectively with average 46.52%, while on 2/8 the minimum and maximum concentrations were 9$\mu g/m^3$(7.00 am) and

137 µg/m^3(11.00 am), respectively with average 36.6%. For Ozone (O_3) the study revealed also lower concentrations of O_3 where on 15/7, the minimum and maximum emissions were 9.1 µg/m^3 (5.30 am) and 39.4 µg/m^3, (8.00 pm) respectively with average 7.58% while, on 2/8 the emissions were 3.1 µg/m^3 (9.30 am) and 31.0 µg/m^3 (5.00 pm), respectively with average 2.6 %. All data were tabulated in Tables [3&4]. Figures [1&2] show also the variations in concentrations for all pollutants. The particulate matters PM 10 and PM 2.5 concentrations were also lower than WHO guideline levels, USNAAQS and the Egyptian law No. 4 guideline levels. The minimum and maximum concentrations of PM 2.5 on 15/7 were 29 µg/m^3 (3.00 pm) and 75 µg/m^3 (7.30 am), respectively with average 36.25%, while on 2/8 the concentrations were 25 µg/m^3 (7.00 am) and 47.5 µg/m^3 (8.00am), respectively with average 31.25%. On the other hand, the minimum and maximum concentrations of PM 10 on 15/7 were 31 µg/m^3 (3.00 am) and 89 µg/m^3 (7.30 am), respectively with average 36.25%, while on 2/8 the concentrations were 28 µg/m^3 (7.30 am) and 57.5 µg/m^3 (4.30 am), respectively with average 18.7 %.The min. temperature and humidity were 25^{o}C and 29.1 while the maximum temperature and humidity were 36.8^{o}C and 77.6 for the first measurement on 15/7, while on 2/8 the min temperature and humidity were 22.4^{o}C and 36.7 while the max. temperature and humidity were 37.6^{o}C and 79.5, respectively. In conclusion, we do not know why some ambient air pollutants in our study are low. We believe that the climatic conditions in the studied areas may facilitate adsorption of gas phase pollutants onto PM although PM concentrations were found to be low also in the current study. This may explain the observed low concentrations of CO,NOx and O_3. In fact, we recognize that our findings cannot be directly compared with WHO and USEPA air quality standards due to differences in averaging times. However, our findings are comparable with Maximum Permissible Limits according to Egyptian law No. 4 for 1994 for environment protection and its amendments by law No. 9 for 2009 and its executive regulation board

issued in 2011 and 2012. We could not measure concentrations at multiple sites at the same time. Therefore, we were unable to differentiate spatial variation from temporal variation in concentrations. The current study considered that the temporal variations of air pollutant concentrations could not be assessed, which is a major limitation of this pilot study, especially for H_2S. As for the hydrogen sulfide gas, the concentrations recorded exceeded the limits of the guidelines, which make us believe that the unpleasant odors complained by the population at night and during the burning are caused by the emission of hydrogen sulfide (H_2S) gas in addition to sulfur dioxide (SO_2).

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Table (1)
Ambient Air Quality (Maximum limits of outdoor air pollutants (Egyptian Law 9/2009).

Pollutant (Urban areas)	**Maximum Limit (µg/m3)**	**Averaging Time**
Sulphur Dioxide (SO_2)	300	1 Hour
	125	24 Hour
	50	Annual
Hydrogen sulfide (H_2S)	-	-
Carbon Monoxide (CO)	30.00 (mg/m^3)	1 Hour
	10.00 (mg/m^3)	8 Hour
Nitrogen Dioxide (NO_2)	300	1 Hour
	150	24 Hour
	60	Annual
Nitrogen Monoxide (NO)	-	-
PM10	150	24 Hour
	70	Annual
PM2.5	80	24 Hour
	50	Annual
Ozone (O_3)	180	1 Hour
	120	8 Hour

Table 2
WHO guidelines levels sand USEPA (NAAQS) for air pollutants.

Time		24 hrs.			8 hrs.		1 hr.	1/2hr.
Gases	SO2	PM2.5	PM10	CO	O3	NO2	H2S	
	µg/m3			mg/m3		µg/m3		
WHO	20	25	50	10	100	200	7*	
USEPA	150	35	150	9	150	200	42**	

*WHO, 1981. Hydrogen sulfide. World Health Organization, Environmental Health Criteria NO. 19. Geneva.

**Ambient Air Guidelines for H2S, CAS Registry Number: 7783-06-4, March 27, 2006.

Table 3
Overall data on ambient air qualityat Al-Asmarat Discrete on 15-16 July 2018

Time	CO (mg/m^3)	SO_2 ($\mu g/m^3$)	H_2S ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	O_3 ($\mu g/m^3$)	NO ($\mu g/m^3$)	PM 2.5 ($\mu g/m^3$)	PM10 ($\mu g/m^3$)
12:00 PM	0.609	101	111	75	33.1	21	47	60
12:30 PM	0.551	115	88	99	31.6	45	46	55
1:00 PM	1.15	118	112	120	25	95	40	50
1:30 PM	1.593	119	165	139	17	91	31	35
2:00 PM	1.243	90	145	141	12.3	68	31	39
2:30 PM	0.989	46	133	142	12.2	47	31	36
3:00 PM	1.152	34	88	140	15.1	78	29	31
3:30 PM	0.84	36	180	68	24	35	32	34
4:00 PM	0.775	3	85	89	23.2	42	33	40
4:30 PM	1.559	13	233	71	33.7	67	37	45
5:00 PM	0.882	24	190	65	27.9	67	35	42
5:30 PM	0.889	21	160	59	29.5	78	35	45
6:00 PM	0.89	20	160	58	31	91	36	47
6:30 PM	0.895	20	166	57	34.3	84	36	47
7:00 PM	0.812	56	175	69	38.7	88	37	45
7:30 PM	1.24	45	263	87	37.7	98	44	53
8:00 PM	1.387	19	173	110	39.4	73	45	56
8:30 PM	1.362	18	251	106	31.6	57	47	59
9:00 PM	1.6	38	270	96	34.5	31	49	61
9:30 PM	1.21	41	210	90	32.5	28	51	65
10:00 PM	1.02	51	190	85	29	25	56	69
10:30 PM	0.81	60	120	82	20	22	58	70
11:00 PM	0.697	66	116	80	12.5	21	60	72
11:30 PM	0.85	50	145	119	15.4	21	59	71
12:00 AM	0.95	45	179	110	17	71	58	72
12:30 AM	1.05	39	179	115	17	71	56	71
1:00 AM	1.05	35	181	103	19.9	72	58	73
1:30 AM	1.183	9	187	117	20	73.9	61	74
2:00 AM	1.02	10	170	95	21	75.2	65	76

Cont. Table 3

2:30 AM	0.552	16	154	69	20	77.6	68	78
3:00 AM	0.561	27	142	71	21	75.2	65	77
3:30 AM	0.617	41	131	15	19.1	69	63	75
4:00 AM	0.697	66	116	8	12.5	65.4	61	74
4:30 AM	0.673	47	144	12	9.5	65.2	67	77
5:00 AM	0.599	32	150	14	9.9	64.8	60	71
5:30 AM	0.671	35	95	24	9.1	63	65	75
6:00 AM	0.681	37	85	31	9.8	62.5	67	73
6:30 AM	0.691	34	72	38	15	62	71	79
7:00 AM	0.72	33	62	39	17	62	74	85
7:30 AM	0.8	32	59	45	18	61.5	75	89
8:00 AM	0.781	18	141	14	17.6	58	71	83
8:30 AM	0.835	33	144	8	16	56	69	78
9:00 AM	0.894	29	172	23	16.2	54.3	64	74
9:30 AM	1.132	48	199	7	17.8	49.8	63	75
10:00 AM	0.949	32	188	55	18.6	46.5	56	71
10:30 AM	0.931	47	196	70	16.3	45	55	70
11:00 AM	1.19	82	147	74	27.8	42.8	59	73
11:30 AM	0.697	66	116	8	12.5	45.4	60	72

Table 4
Overall data on ambient air quality at Al-Asmarat Discrete on 2-3 August 2018

Time	CO (mg/m^3)	SO_2 ($\mu g/m^3$)	H_2S ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	O_3 ($\mu g/m^3$)	NO ($\mu g/m^3$)	PM 2.5 ($\mu g/m^3$)	PM10 ($\mu g/m^3$)
7:00 PM	1.49	253	167	9	20.3	98	25	30
7:30 PM	1.44	212	211	12	20.9	71	27	28
8:00 PM	1.51	158	279	19	21	51	31	38
8:30 PM	1.38	138	317	20	29.3	81	25	30
9:00 PM	1.38	136	293	46	23.7	75	32	39
9:30 PM	1.1	126	207	48	20	72	38	45
10:00 PM	1.49	11.9	285	59	26.5	48	40	50
10:30 PM	1.39	19	295	57	25.5	54	42	53
11:00 PM	1.36	20	303	56	24.6	64	44	54
11:30 PM	1.35	50	308	59	24.7	62	45	54.5
12:00 AM	1.24	45	309	61	25	61	45	55
12:30 AM	1.29	50	311	64	25.1	60	46	55.4
1:00 AM	1.21	80	321	67	25.6	58	47	56
1:30 AM	1.24	100	324	68	25.2	58	46.5	56.5
2:00 AM	1.22	120	331	69	25.4	57	46	57
2:30 AM	1.24	140	319	70	25.6	56	45.8	57
3:00 AM	1.19	190	312	69	25.7	55	45.5	56
3:30 AM	1.19	229	317	66	25.5	54	45	56.5
4:00 AM	1.21	295	321	61	25	53	45.5	57
4:30 AM	1.19	324	324	59	24.8	52	46	57.5
5:00 AM	1.14	385	315	57	24.6	52	46.5	57
5:30 AM	1.17	410	310	58	24.1	51	46.5	56.5
6:00 AM	1.15	418	305	56	23	50	47	56.5
6:30 AM	1.1	429	291	54	20.9	49	47.5	56
7:00 AM	1.14	459	285	57	18.9	49	47	56.5
7:30 AM	1.14	495	270	58	18	50	47.5	57
8:00 AM	1.1	511	240	59	17.6	51	47.5	57
8:30 AM	1.076	519	232	60	11.4	50	47	57
9:00 AM	1.322	516	331	30	6.9	72	45	56

Cont. Table 4

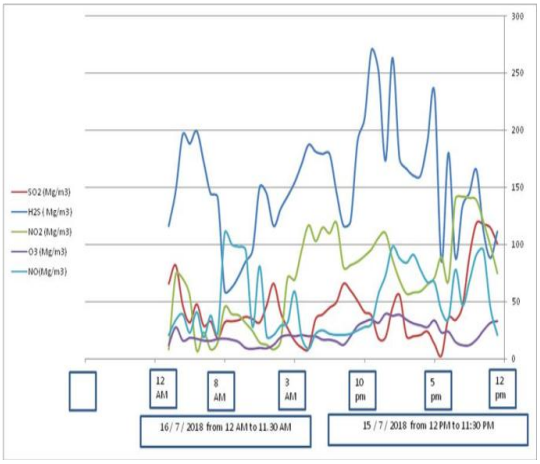
9:30 AM	1.381	426	334	90	3.1	32	43	55
10:00 AM	1.395	389	321	85	3.6	72	42	52
10:30 AM	1.263	220	238	95	8.1	100	38	45
11:00 AM	0.925	200	214	137	8.7	62	32	38
11:30 AM	0.735	171	173	104	10.6	76	32	35
12:00 PM	0.621	146	196	66	17.4	62	33	36
12:30 PM	0.66	62	160	78	18.5	102	31	35
1:00 PM	0.721	71	199	54	18.4	60	28	30
1:30 PM	0.622	37	190	69	22	104	32	36
2:00 PM	0.635	42	183	53	23.1	50	34	42
2:30 PM	0.731	31	150	55	25.8	94	32	39
3:00 PM	0.598	34	175	36	29.7	61	38	46
3:30 PM	0.601	36	180	41	29	56	39	47
4:00 PM	0.65	70	179	40	30	58	38	45
4:30 PM	0.71	90	177	38	31	59	37	42
5:00 PM	0.92	125	180	36	31	62	35	39
5:30 PM	1.19	165	179	30	28	66	32	36.5
6:00 PM	1.25	210	175	28	25	71	29	34
6:30 PM	1.39	231	170	20	21	76	27	32

Table 5:
Air Pollutants Values of the studied air pollutants in Comparison with Environmental Protection Law No. 9 for 2009 and its Executive Board modified at 2012.

Parameters	CO (mg/m^3)	SO2 ($\mu g/m^3$)	H_2S ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	NO ($\mu g/m^3$)	O_3 ($\mu g/m^3$)	PM 2.5 ($\mu g/m^3$)	PM10 ($\mu g/m^3$)
				15/7/2018				
Min.	0.551	3.00	59	7	9	9.1	29	31
Max.	1.60	119	270	140	110	39.4	75	89
Average	0.928	42.86	151	69.8	48.8	21.4	52.35	62.71
				Ratio of Ambient Limits				
	5.51 %	2.4%	-	4.67%	-	7.58%	36.25%	20.67%
	16 %	95.2 %	-	94.6 %	-	32.8 %	93.75 %	59.3 %
	9.28 %	34.29 %	-	46.52 %	-	17.84 %	36.25 %	20.67 %
				2/8/2018				
Min.	0.598	11.9	150	9	32	3.1	25	28
Max.	1.51	519	334	137	104	31	47.5	57.5
Average	1.10	196.1	252	55	62.6	21.2	38.9	46.7
				Ratio of Ambient Limits				
Min.%	5.98 %	9.52%	-	6%	-	2.6%	31.25%	18.7%
Max. %	15.1 %	415 %	-	91.3 %	-	25.8 %	59.4 %	38.3%
Average%	11.02 %	156 %	-	36.6 %	-	17.7 %	48.6 %	31.1 %
Limits (Law 9/2009)	10.00	125	-	150	-	120	80	150

Fig 2: (SO_2, H_2S, NO, NO_2, O_3) Chart

First measurement on 15-16/7/2018, Second measurement on 2-3/8 /2018



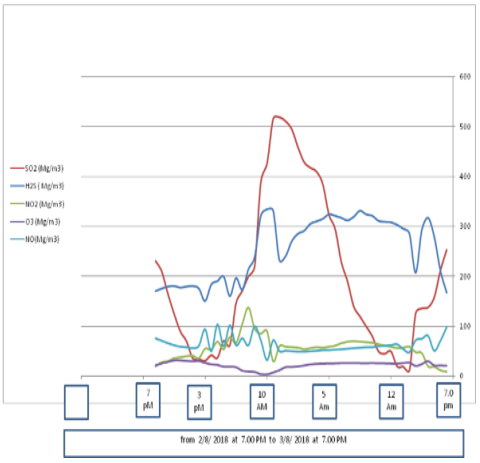
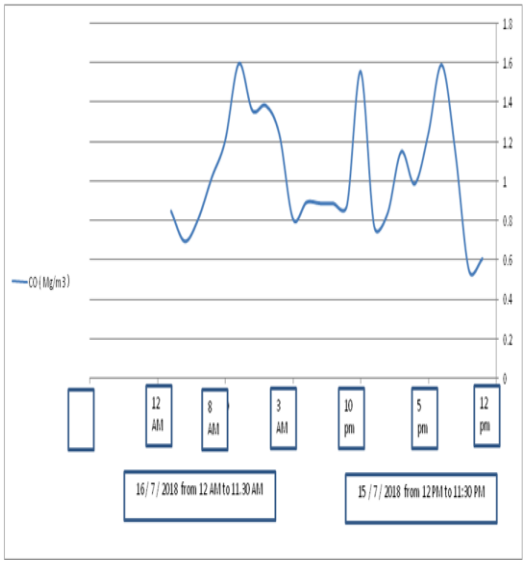


Fig 3: (CO) Chart

First measurement on 15-16/7/2018, Second measurement on 2-3/8/2018.



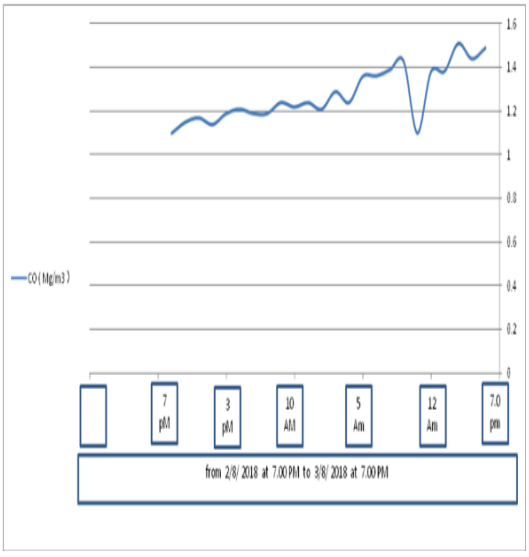
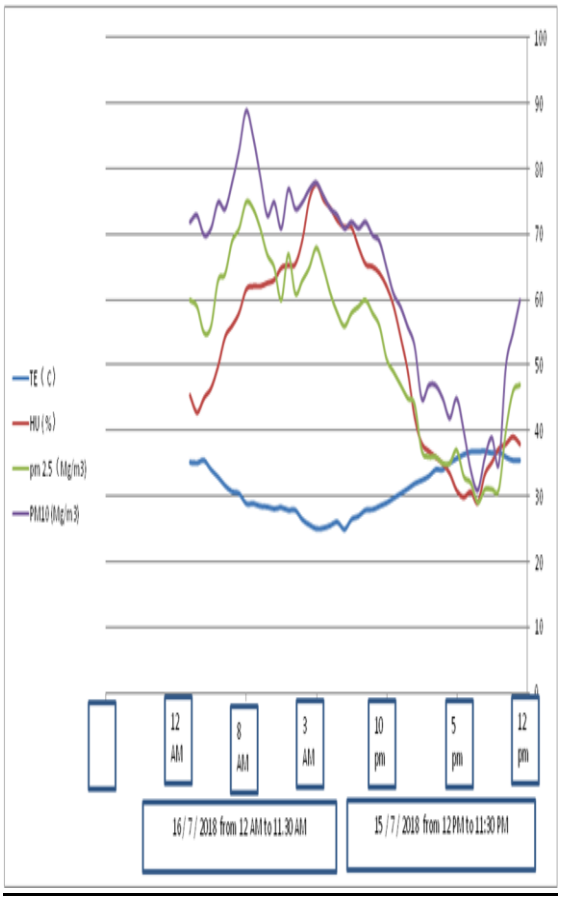


Fig 3: (PM 2.5&10, Hu% and TE ^{o}C) Chart

First measurement on 15-16/7/2018,



Second measurement on 2-3/8/2018.