Evaluation of Traffic Gaseous Pollutants in Damietta City-Egypt

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Abstract: Air pollution caused by vehicular traffic has long been identified as a community problem. Urban air pollution on the street level depends largely on traffic density. Therefore, this study assesses and discusses the current and future contribution of road traffic to main precursors such as NO_2, SO_2, NH_3 and O_3. In the present study, road traffic emissions were investigated for seven sites in Damietta City, Egypt which was considered to have different traffic flows. Gaseous pollutants; SO_2, NO_2, O_3, and NH_3 were monitored for urban locations at two heights; street-level (A) and 6m±2 high rooftop (B). The maximum annual mean concentration at street level of SO_2 (77.29 µg/m^3) and of O_3; (705.53 µg/m^3) exceeded the Egyptian Ambient Air Quality Standard (EEAA: 60 and 120 µg/ m^3), respectively, but were lower than for NO_2 (84.39µg/m^3) and NH_3 (29.41 µg/m^3) (US: 100 µg/m^3 and air quality standard in Poland: 45 µg/m^3, respectively). [Journal of American Science 2010; 6(9):911-923]. (ISSN: 1545-1003).

Keywords: Traffic pollution; Damietta; Gases; SO_2, NO_2, O_3, and NH_3.

1. Introduction:

Motor vehicles play a conspicuous role in the modern industrial economy and in shaping our natural and built environment. Cars and light trucks offer rapid, reliable, and convenient mobility on demand to an ever-growing number of people in countries throughout the world. Nevertheless, for all their positives, automobiles carry with them many negatives. No one disputes that motor vehicles collectively contribute to a number of important and pressing social problems. Road transport became a significant source of air pollution in the last century and is currently one of the largest emission sources in megacities with subsequent adverse effects on human health. The health effects attributable to inhalation of emissions are only one of the many impacts associated with motor vehicles (Delucchi, 1996).

Gaseous pollutants are mainly produced by the combustion of fuels and the vaporization of volatile fuels, etc. because of their impact on the atmosphere, vegetation, human health and materials, gases have received considerable research and regulatory attention. Approximately 90% of the anthropogenic emissions to the atmosphere are gaseous (Godish, 1997).

Recently, United Nations estimate that 47% of the global population is living in urban areas (Sydbom *et al.,* 2001). Therefore, urbanization has brought with it an increased need for transportation and hence an increase in motor vehicle generated air pollutants. They also contribute to global warming, accounting for a large and growing share of greenhouse gas emissions worldwide (Harrington and McConnell, 2003). Cities around the world face serious traffic congestion problems as the number of vehicles and the need for transportation grow. Traffic congestions do not only cause considerable costs due to unproductive time losses; but they also increase the probability of accidents as well as have negative impacts on the environment; air pollution, lost fuel, and on the quality of life health problems, noise, stress. Despite significant improvements in fuel and engine technology, exhaust after-treatment and fuel composition, present day urban air environments are still mostly dominated by traffic emissions (Nazridoust and Ahmadi, 2006). The traffic management and control have been a major problem in developing as well as developed countries (Almejalli *et al.,* 2007).

The rapid population growth together with high rate of urbanization, industrialization and increase in motorized transport have resulted in an increased concentration of various air gaseous pollutants namely; sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ozone (O_3), etc. (Goyal *et al.,* 2006).

Sulfur dioxide is considered to being the most important air pollutant, because it is the most universally distributed and is associated with high corrosion rates plant damage and general toxic effects. SO_2 is a classical air pollutant associated with fuel consisting of sulphur impurities. Diesel vehicles are main sources for SO_2 emissions, it can successfully be reduced using fuels with low sulphur content (Khare and Nagendra, 2007). While agriculture, particularly livestock farming, represents the main source of ammonia (NH_3), traffic might be the most important factor influencing ammonia concentrations at urban locations and near roads (Sutton *et al.,* 2000; Löflund *et al.,* 2002).

Fuel combustion represents the major source of man-made nitrogen oxides (NO_x). Although in the last 10 years emissions by gasoline powered cars could be reduced significantly following the introduction of the three-way catalytic converters (Kean *et al.,* 2000), nitrogen oxides emissions remain a problem for the environment because of the increasing road traffic in general and the increasing portion of diesel cars and heavy duty vehicles. NO_2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. The most adverse health effect linked to NO_2 occurs at the junction of the lungs. Exposure of NO_2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function (Khare and Nagendra, 2007). However, Ozone is formed in the atmosphere owing to photochemical reactions involving organic compounds and oxides of nitrogen, it is produced by action of light on nitrogen oxides under the influence of U.V. rays, a nitrogen dioxide molecule generates one atomic oxygen. Ozone (O_3) is a strong oxidizing gas, it causes eyes and lung irritations; coughs and respiratory troubles; and contributes to the greenhouse effect and vegetation degradation (Cooper *et al.,* 1998; Brunet *et al.,* 2001).

The adverse effect of pollution from vehicles gets revealed immediately through symptoms like cough, headache, nausea, and irritation of eyes, various bronchial problems and visibility impairment. Long-term exposure to the high level of pollutants is mainly responsible for respiratory and other ailments including lung cancer, asthma and in some cases leading to death. (Goyal *et al.,* 2006).

In developed countries, governments have fought for clean air by regulating all major and many minor sources of air pollution. Limited resources, invested for the development of transport facilities, such as infrastructure and vehicle, coupled with the rapid rise in transport demand, lack of application of adequate and proper traffic management schemes are producing severe transport problems in almost all the urban areas. However, no detailed study concerning traffic congestion and air pollution problems for urban areas of Damietta City has yet been done.

The present study was designed in order to make detailed characterization and quantification of motor vehicle related air pollutants along an urban street in Damietta City, measurement of gaseous pollutants, was accomplished. The objective of this study to investigate the air quality and the role of traffic-related pollution in the City.

2. Methodology:

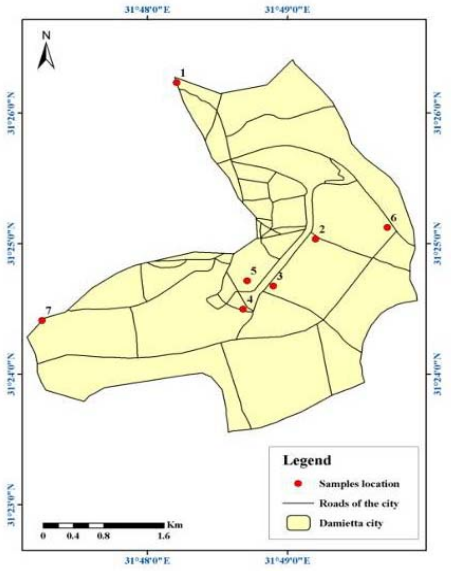
The Study Area:

This study was carried out in Damietta City. Damietta City is the capital of Damietta Governorate and one of the largest cities of Egypt, counts with a population of approximately 92 thousand inhabitants. The City is located at the north of the Governorate. Damietta Governorate lies between latitude 31.26 N and longitude 31.48 E and locates in the north of the Delta near the sea shore at the end of the River Nile. It lies 15 km from the Nile estuary, and the River Nile "Damietta sector" separates it into two parts surrounded by The Mediterranean Sea to the north, Al-Manzala Lake to the east, and the Delta farms and plains to the south and the west. It covers an area of 1029 km^2 and has a population of approximately one million inhabitants (Damietta Governorate; the administration of the public relations, 2003) (Map 1).

It has a climate of Mediterranean Sea area with hot arid summer and moderate rain winter, a rainy season from November to April, and a dry season from Julia to September. Ambient mean temperatures are especially high in the dry season when they range between 25 and 30 C with average temperature, 22°C and the difference between the average temperature in summer and winter is 6°C. In the summer, Mediterranean Sea air blows and moderates the temperature, while in the winter the western wind blows on the north of the Delta that is carrying rainy clouds and passes the coast resulting in rainfall on the Delta. Moreover, spring months characterized by the passage of "Khamasin" dust laden winds, which is a local hot, dry, and dust-laden winds and are mainly southerly and easterly winds, occur frequently during the period of February through June (Sowelim, 1965).

Air pollution in Damietta City, which is categorized as urban site, comes from a great variety of light industries; such as shoes, diary, textile, sweets industries, and in addition to the different activities of workshops (furniture and painting workshops), as well as from fuel combustion in vehicles. There is no heavy industries in Damietta City, is therefore, heavy commercial activities and motorized vehicles emissions are major contributors of polluted air in many urban areas of air pollutants in the City. To be able to characterize to what extent the traffic or different vehicle types contribute to the city pollution detailed information of the emissions is needed.

Map (1): Location Map of the Study Area (Damietta City).



Map (2): Samples Locations of Gaseous Pollutants

Locations:
1- Al-Harby Street, (Site 1),
2- Bab Al-Haraas, (Site 2),
3- El-Matary Bridge, (Site 3),
4- Abd Al-Raheem Nafea Street, (Site 4),
5- Souror Square, (Site 5),
6- Gheit El-Nasara, (Site 6), and
7- Damietta Lock and Gates Bridge, (Site 7).

Sites and Sampling Strategy:

In order to investigate the air quality and the role of traffic related pollution during a period of one year (Starting from February 2008 to January 2009) in Damietta City, Egypt. Seven sites were selected in the urban area of in the City to calculate the concentrations of gaseous pollutants; sulfur dioxide (SO_2), nitrogen dioxide (NO_2), total oxidants (O_3) and ammonia (NH_3). Daily for 24 hours measurements of gaseous concentrations ware monitored (Once a week) at two heights in an urban canyon at street-level (A) and at 6m±2 high rooftop (B).

Samples were collected and identified from selected sites using Global Positioning System (GPS) (Map 2), as follow: Al-Harby Street (location 1), Bab Al-Haraas (location 2), El-Matary Bridge (location 3), Abd Al-Raheem Nafea Street (location 4), Souror Square (location 5), Gheit El-Nasara (location 6), and Damietta Lock and Gates Bridge (location 7). Locations 6 and 7 were chosen for the purpose of comparison, outside the potential influence of high traffic; Gheit El-Nasara and Damietta Lock and Gates Bridge. Sampling sites were located on both sides of a street at a distance of ≥3m from the traffic lanes, in order to be outside of the traffic induced mixing zone (Coe *et al*, 1998). The sample intake was placed at round 1.5 m to characterize pollution near the standing breathing zone.

Statistical analysis:

The statistical analysis was performed using Excel Microsoft 2007 and SPSS version 12 programs. This represents the descriptive statistics. Correlation coefficients as well as the derived equations from the relationships between the related parameters were also calculated.

Determination of Gaseous Pollutants (SO_2), (NO_2), (O_3) and (NH_3):

West and Gaeke method (Pararosaniline Method) is applied for determination of sulfur dioxide calorimetrically at λ= 548 nm (Lodge and Editor, 1998). Nitrogen Dioxide (NO_2) gas was measured by Sodium arsenite method and then determined calorimetrically at λ= 540 nm. Neutral Potassium Iodide Method was used for O_3 gas measurements calorimetrically at λ = 352 nm. Ammonia (NH_3) was measured by using (Indophenol-Blue Method) by reaction with phenol and alkaline sodium hypochlorite to produce indophenol, a blue dye and then determined calorimetrically at λ = 630 nm (Harrison and Perry, 1986).

3. Results and Discussion:

Tables 1 (a and b) present the annual mean concentrations of gases (SO_2, NO_2, O_3 and NH_3) at

two heights, street-level about 1.5 m from the ground (A) and at about 6 m±2m high rooftop (B) , at different investigated sites in urban areas over Damietta City.

Table (1-a): Annual Mean Concentrations of Gases (SO_2 and NO_2) in the Atmosphere of Investigated Sites over Damietta City from February 2008 to January 2009.

Site	SO_2				NO_2			
	Concentrations (µg/m³)		Reduction Ratio (%)	Enrichment Factor (%)	Concentrations (µg/m³)		Reduction Ratio (%)	Enrichment Factor (%)
	A	B			A	B		
1	77.29±53.54	47.97±39.00	38.85	89.88	69.44±38.16	58.60±37.38	17.91	28.60
2	75.44±57.39	52.12±43.41	29.72	55.28	84.39±33.04	70.02±27.54	17.27	21.59
3	59.08±42.17	35.57±19.08	34.31	63.02	74.58±32.50	60.09±33.05	21.73	44.24
4	51.63±34.81	25.32±10.49	42.89	97.93	71.43±31.09	59.20±29.76	17.74	26.38
5	65.06±41.83	35.36±37.60	50.84	139.50	66.34±36.74	57.29±35.58	17.56	25.20
6	25.41±12.13	15.21±7.95	40.66	72.20	31.24±12.47	25.27±11.22	20.62	26.73
7	31.26±15.59	19.72±8.37	34.36	59.03	29.55±11.25	22.73±10.34	24.05	34.55
Max.	77.29±53.54	52.12±43.41	50.84	139.50	84.39±33.04	70.02±27.54	46.12	97.38
Min.	25.41±12.13	15.21±7.95	29.72	55.28	29.55±11.25	22.73±10.34	17.41	25.03
A.Q.S.	US and EEAA =60 µg/m³ (Annual mean).				US = 100 µg/m³ (Annual mean).			

A = Street Level (1.5 m from the ground), B = 6m±2 (High rooftop).
A.Q.S. = Air Quality Standard.

Annual Concentration of Sulfur Dioxide (SO_2) at the Different Sites

The average annual mean concentration of SO_2 over Damietta City atmosphere was 44.03±30.24 µg/m³. This concentration is 3.4 times higher than the concentration of 13 µg/m³ recorded in Boston-USA (Jonnalagadda *et al.,* 1992) and about 2.3 times above the value of 19.2 µg/m³ that recorded in Finland (Ponka, 1991).

The mean annual concentrations of SO_2 at street level (A) during the study period were 77.29, 75.44, 59.08, 51.63, 65.06, 25.41 and 31.26 µg/m³ at sites 1, 2, 3, 4, 5, 6 and 7, respectively. The maximum annual mean concentration of SO_2 at street level (A) was 77.29 µg/m³ recorded at Al-Harby Street (Site 1) followed by 75.44 µg/m³ recorded at Bab Al-Haraas Road (Sites 2) (Table 1-a). These concentrations were above the Egyptian Ambient Air Quality Standard and the US Ambient Air Quality Standard (60 µg/m³) (Colls, 1997; EEAA, 1995).

These high concentrations at sites (1 and 2) are possibly due to the high traffic and population densities and commercial activities in these districts. On the other hand, the lowest mean concentration of SO_2 (25.41µg/m³) was detected at Gheit El-Nasara street (Site 6). It is a residential area, characterized as a cultivated area with about 6 m wide. It is uni-directional traffic flow which characterized by low traffic density and low work activities. The median values of daily SO_2 concentration ranged from 28 µg/m³ to 110 µg/m³ at the streets level (A) at different investigated sites. The frequencies of daily concentrations of SO_2 levels, expressed as percentage from the total number of daily samples, at different investigated sites indicated that about 50 % of the measured samples for sites 1 and 2 and (20, 30, 30 and 10 %) for sites 3, 4, 5 and 7, respectively, were above the Egyptian and US National air quality standard (60 µg/m³) (Figure 1).

Whereas, the mean annual concentrations of ambient SO_2 at level (B) (6m±2 above the ground level) were 47.97, 52.12, 35.57, 25.32, 35.36, 15.21 and 19.72 µg/m³ at sites 1, 2, 3, 4, 5, 6 and 7, respectively (Table 1-a). Therefore, comparing the concentrations of SO_2 at the two levels A and B, indicated that the concentrations of SO_2 increase at level (A) than that recorded for level (B) in all investigated sites, with a reduction ratio (%) (50.84, 42.89, 40.66, 38.85, 34.36, 34.31 and 29.72 %) recorded for sites 5, 4, 6, 1, 7, 3 and 2, respectively. On the other hand, enrichment factors (%) were (139.50, 97.93, 89.88, 72.20, 63.02, 59.03 and 55.28 %) for sites 5, 4, 1, 6, 7, 3 and 2, respectively (Table 1). The maximum annual mean of enrichment factor for SO_2 (139.50 %) recorded at a heavily trafficked street, Souror Square (site 5). This may be explaining the high enrichment factor recorded at this site. This clearly indicates that traffic emission seem to be the main source of atmospheric SO_2. Consequently, traffic and local sources of human activities are the main sources of sulfur dioxide recorded in the city atmosphere.

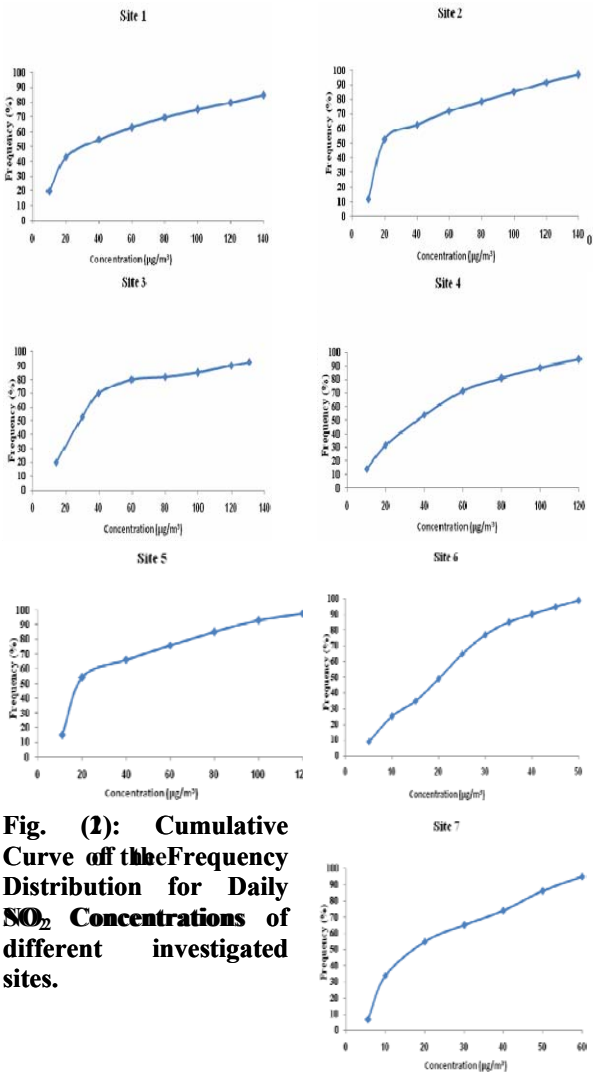


Fig. (2): Cumulative Frequency Curve of the Distribution for Daily NO_2 Concentrations of different investigated sites.

Annual Concentrations of Nitrogen Dioxide (NO_2) at the Different Sites

The average annual mean concentration of NO_2 (55.73±24.14 µg/m^3) over Damietta City atmosphere is below the US national ambient air quality standards (100 µg/m^3). However it is about 1.4 times above the concentration (40 µg/m^3) found in Boston (Brauer *et al.,* 1991) and 1.5 times above the 38 µg/m^3 detected in Yanbu-Saudi Arabia (Rowe *et al.,* 1991). It is also about 1.1 times more than the Switzerland and EEC standards set for NO_2 (50 µg/m^3) (Nriagu and Simmons, 1994).

The mean annual concentrations of NO_2 at street level (A) during the study period were 69.44, 84.39, 74.58, 71.43, 66.34, 31.24 and 29.55 µg/m^3 at sites 1, 2, 3, 4, 5, 6 and 7, respectively (Table 1-a). It can be noticed that the maximum annual mean concentration of NO_2 at street level (A) was 70.02 µg/m^3 followed by 60.09 µg/m^3 recorded at the high traffic and population densities sites (2 and 3), respectively. These concentrations were below the US national ambient air quality standards (100 µg/m^3). On the other hand, the lowest mean concentration of NO_2 was 29.55 µg/m^3 detected at a very low population density street, site (7). The median values of daily NO_2 concentrations ranged from 28 µg/m^3 to 70 µg/m^3 at the streets level (A) at different investigated sites. The frequencies of daily concentrations of NO_2 levels at different investigated sites indicated that about 40 %, 28 %, 20 %, 28 %, 24 % and 5 % of the measured samples recorded for sites 1, 2, 3, 4, 5 and 7, respectively, were above the US air quality standard (100 µg/m^3) (Colls, 1997) (Figure 2).

On the other hand, the mean annual concentrations of ambient NO_2 at level (B) over the City atmosphere were 58.60, 70.02, 60.09, 59.20, 57.29, 25.27 and 22.73 µg/m^3 at sites 1, 2, 3, 4, 5, 6 and 7, respectively. Therefore, comparing the concentrations of NO_2 at the two levels A and B, show that the concentrations of NO_2 increase at level (A) than that recorded for level (B) in all studied sites with a reduction ratio (%) (24.05, 21.73, 20.62, 17.91, 17.74, 17.56 and 17.27 %) recorded for sites 6, 3, 7, 1, 4, 5 and 2, respectively. However, enrichment factors (%) were (44.24, 34.55, 28.60, 26.73, 26.38, 25.20 and 21.59 %) for sites 3, 7, 1, 6, 4, 5 and 2, respectively (Table 1-a). This clearly indicates that traffic emission is the main source of atmospheric NO_2. This is in agreement with Laffray *et al.* (2010) who reported that NO_2 and NO_x concentrations gradually declined with increasing distance from the two road axis. The steepest nitrogen oxide concentration decrease occurred within 150 m. Thus, nitrogen oxides concentrations were negatively correlated to the distance from the road axis. On the other hand, Gilbert *et al.* (2003) demonstrated that that the distance from the roadway may be a valid surrogate variable for at least some traffic related air pollutants.

Table (1-b) presents the annual mean concentrations of gases (O_3 and NH_3) at two heights, street-level about 1.5 m from the ground (A) and at about 6 m±2m high rooftop (B), at different investigated sites in urban areas over Damietta City.

Table (1-b): Annual Mean Concentrations of Gases (O_3 and NH_3) in the Atmosphere of Investigated Sites over Damietta City from February 2008 to January 2009.

Site	O_3				NH_3			
	Concentrations (µg/m^3)		Reduction Ratio (%)	Enrichment Factor (%)	Concentrations (µg/m^3)		Reduction Ratio (%)	Enrichment Factor (%)
	A	B			A	B		
1	603.62±451.20	324.42±276.92	41.60	122.88	26.47±18.04	16.94±9.46	28.84	50.72
2	705.53±530.61	411.82±318.67	31.63	70.06	26.16±18.27	17.85±9.63	25.98	41.06
3	630.95±464.13	358.59±297.56	38.25	100.07	24.57±13.19	16.66±7.70	24.51	62.58
4	492.50±354.33	358.68±290.98	27.54	46.48	29.41±21.13	22.94±16.46	21.95	35.14
5	551.13±428.66	299.91±215.34	35.07	77.81	27.17±21.70	15.32±8.30	35.08	78.87
6	48.52±17.75	29.08±17.17	43.49	89.78	15.76±8.72	10.10±6.47	37.31	62.62
7	54.74±17.63	34.20±15.61	39.17	68.13	21.05±9.52	12.97±5.95	38.25	65.50
Max.	705.53±530.61	411.82±318.67	43.49	122.88	29.41±21.13	22.94±16.46	35.08	78.87
Min.	48.52±17.75	29.08±17.17	27.54	46.48	15.76±8.72	10.10±6.47	21.95	35.14
A.Q.S.	EEAA =120 µg/m3 (8hrs).				A.Q.S. in Poland =45 µg/m3, A.Q.S. in Germany =100 µg/m3.			

A = Street Level (1.5 m from the ground), B = 6m±2 (High rooftop).
A.Q.S. = Air Quality Standard.

Annual Mean Concentration of Ozone (O_3) at the Different Sites

The average annual mean concentration of O_3 (350.26 ± 264.04 µg/m^3) is 12 times above (EEAA of the maximum allowable O_3 for 8-houre: 120 µg/m^3) (EEAA, 1995). These high results may be attributed to the accumulation of high concentration of O_3 precursors gases (NO_2 and hydrocarbons) emitted from combustion of fuels in motor vehicles.

The mean annual concentrations of O_3 at street level (A) during the study period were 603.62, 705.53, 630.95, 492.50, 551.13, 48.52 and 54.74 µg/m^3 at sites 1, 2, 3, 4, 5, 6 and 7, respectively (Table 1-b). It can be noticed that the maximum annual mean concentration of O_3 at street level (A) was 705.53 µg/m^3 recorded at a heavily trafficked road, Bab Al-Haraas, (Site 2) followed by 630.95 µg/m^3 recorded at El-Matary Bridge, (Site 3), may be attributed to that this site is congested street characterized by parking garages for buses and cars. Photochemical oxidants inhalation can cause respiratory track irritation, chest constriction, severe coughing, and inability to concentrate. Ozone also has adverse effects on vegetation (Boubel *et al.*, 1994; Abdel-Latif, 2001). On the other hand, the lowest mean concentration of O_3 (48.52 µg/m^3) was detected at a very low population density site 6 (Table 1-b).

The median values of O_3 concentrations ranged from 50 µg/m^3 to 850 µg/m^3. In addition, the frequencies of 8 hours measurements of O_3 indicated that about (85, 82, 81, 86, and 82 %) of the measured samples recorded for sites 1, 2, 3, 4 and 5, respectively, were above the Egyptian air quality standard (120 µg/m^3, 8-hr) (EEAA, 1995). While the concentration values for sites 6 and 7 below the Egyptian air quality standard (Figure 3).

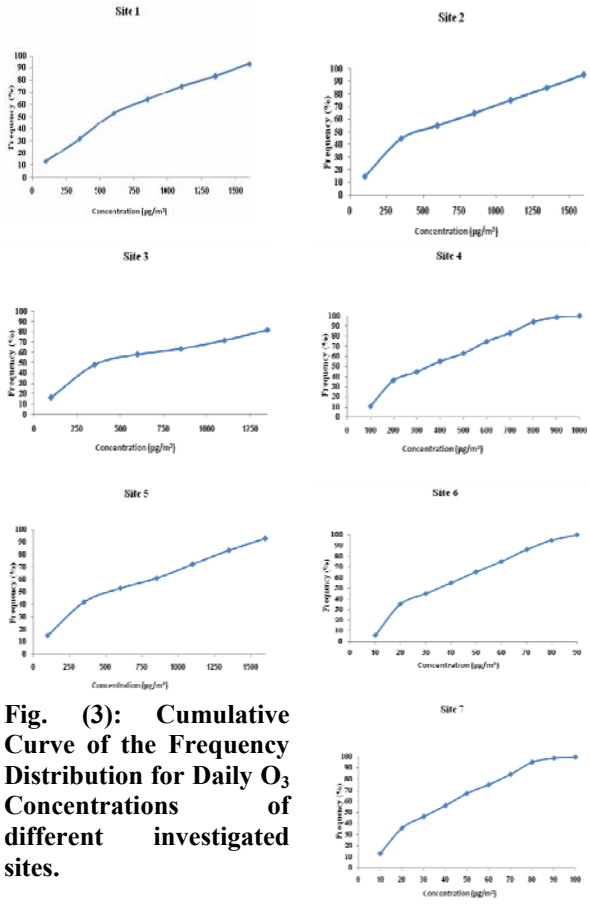


Fig. (3): Cumulative Curve of the Frequency Distribution for Daily O_3 Concentrations of different investigated sites.

The mean annual concentrations of ambient O_3 at level (B) were 324.42, 411.82, 358.59, 358.68, 299.91, 29.08 and 34.20 µg/m^3 at sites 1, 2, 3, 4, 5, 6 and 7, respectively. It is clearly noticed that the concentrations of O_3 increase at level (A) than that recorded for level (B) all studied sites, with a reduction ratio (%) (43.49, 41.60, 39.17, 38.25, 35.07, 31.63 and 27.54%) recorded for sites 6, 1, 7, 3, 5, 2 and 4, respectively. On the other hand, enrichment factors of O_3 were (122.88, 100.07, 89.78, 77.81, 70.06, 68.13 and 46.48 %) recorded for sites 1, 3, 6, 5, 2, 7, and 4, respectively, This clearly indicates that traffic emission is the main source of atmospheric O_3. The maximum annual mean of enrichment factor of O_3 was 122.88 % recorded at Al-Harby Street (Site 1). This may be attributed to that site 1 is a heavily trafficked street and both sides of the street are flanked by buildings.

Annual Mean Concentrations of Ammonia (NH_3) at the Different Sites

The average annual mean concentration of NH_3 over Damietta City atmosphere was 20.24 ± 12.47 µg/m^3 and it is below the air quality standard set in different countries (For example: in Poland =45 µg/m^3, and in Germany =100 µg/m^3) (Stern, 1986). It was similar to the lowest value obtained by Kirchner *et al.* (2005) who observed that concentration peaks between 20 and 70 µg/m^3. On the other hand, annual mean concentration of NH_3 is lower than the values recorded by Perrino *et al.* (2002) that show the average NH_3 concentration at many traffic sites of Rome ranged from 13.5 to 21.6 mg/m^3. Obviously, it can be seen that the annual mean concentrations of ammonia at all the investigated roads in Damietta City were below Air Quality Standard set in different countries (for example: in Poland of 45 µg/m^3) (Stern, 1986**)**. The mean annual concentrations of NH_3 at street level (A) were 26.47, 26.16, 24.57, 29.41, 27.17, 15.76 and 21.05 µg/m^3 at sites 1, 2, 3, 4, 5, 6 and 7, respectively. (Table 1). It can be noticed that the maximum annual mean concentration of NH_3 at street level (A) was 29.41 µg/m^3 followed by 27.17 µg/m^3 recorded at sites 4 and 5, respectively. On the other hand, the lowest mean concentration of NH_3 was 15.76 µg/m^3 detected at a very low population density street, site 6 (Table 1-b).

The median values of daily NH_3 concentrations at the different investigated streets ranged from 20 µg/m^3 to 40 µg/m^3 at street level. However, the frequencies distribution of the all measured concentrations samples of NH_3 indicated that about (20, 30, 10, 15 and 10 %) for sites 1, 2, 3, 4 and site 5 are above the air quality standard in Poland (45 µg/m^3). While the concentration values for sites 6 and 7 are below the air quality standard in Poland (45 µg/m^3) (Figure 4).

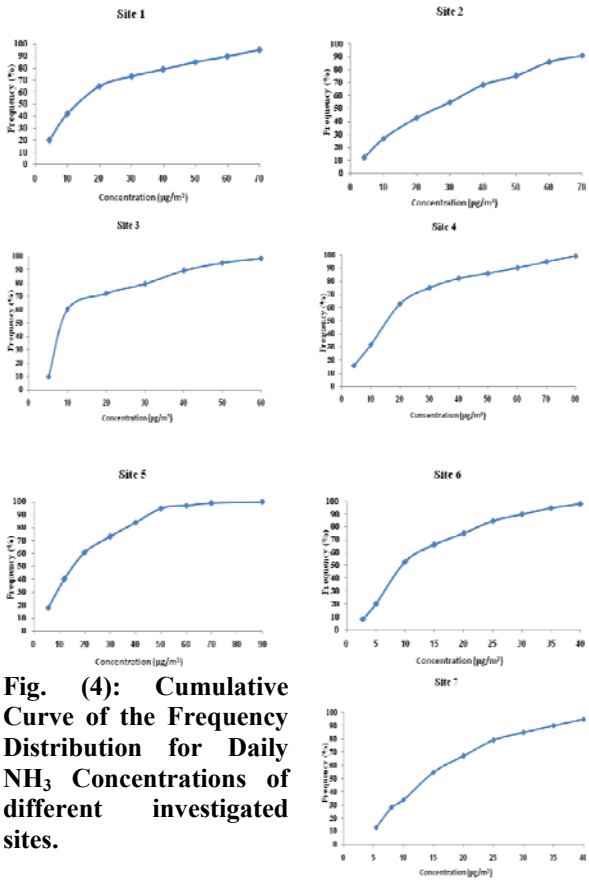


Fig. (4): Cumulative Curve of the Frequency Distribution for Daily NH_3 Concentrations of different investigated sites.

On the other hand, the mean annual concentrations of ambient NH_3 at level (B) were 16.94, 17.85, 16.66, 22.94, 15.32, 10.10 and 12.97 µg/m^3 at sites 1, 2, 3, 4, 5, 6 and 7, respectively. It is clearly noticed that the concentrations of NH_3 increase from level (A) to level (B) in all studied sites, with a reduction ratio (%) (38.25, 37.31, 35.08, 28.84, 25.98, 24.51 and 21.95%) for sites 7, 6, 5, 1, 2, 3, 4, respectively. On the other hand, enrichment factors (%) of NH_3 are 78.87, 65.50, 62.62, 62.58, 50.72, 41.06 and 35.14 % for sites 5, 7, 6, 3, 1, 2, and 4, respectively. This clearly indicates that traffic emission is the main source of atmospheric NH_3. The maximum annual mean of enrichment factor (%) of NH_3 was 78.87 % recorded at site, 5. This street is a congested street and the buildings between the streets of Square act as barriers funneling the air pollutants. It can be concluded that ammonia in these concentrations may have no significant effects but it plays an important role in atmospheric chemistry for its part in the formation of aerosols. Ammonia in the atmosphere can readily react with acid gases as SO_2 and NO_2 (which are present in significant quantities)

and gives fine particulate matter through $(NH_4)_2SO_4$ and NH_4NO_3, which have an adverse effect on health, vegetation, visibility as well as materials. Heinsohn and Kabel (1999) reported that since NH_3 is very soluble, its absorption can precede that of the sulfur dioxide and the result is that the uptake of one component is enhanced by the presence of the other.

Seasonal Variation of Gaseous Pollutants over the Different Sites

Table (2) presents the seasonal mean concentrations of gases (SO_2, NO_2, O_3 and NH_3) at street level (A) over the different sites at Damietta City during the study period.

Temperature and Humidity:

Average temperature and relative humidity over the City during the study period varied from (13.0 to 39.1˚C) and (48.10 to 69.35%), respectively, during the four seasons (Table 2). The highest temperature and relative humidity detected in summer (36.19±0.68˚C) and (62.87±2.30%) followed by spring (36.16±0.91˚C) and (58.80±5.28%), respectively. On the other hand, the minimum seasonal temperature and relative humidity over the City were (21.73±1.05˚C) and (58.50±0.82%) recorded during autumn months followed by winter months, (14.80±0.61˚C) and (56.12±2.65%), respectively.

Seasonal Variation of SO_2, NO_2, O_3 and NH_3 Concentrations

Average SO_2 levels varied from 16.99 to 122.86 µg/m^3 over the four seasons, with the highest concentrations recorded in summer (122.86±60.44µg/m^3), recommended a significant association with temperature and followed by spring season (108.01 ± 67.45 µg/m^3) over the majority of investigated roads (Table 2). This is in agreement with, Eatough *et al.* (1994) who found that the rate of oxidation processes of SO_2 by the OH radical increase with increasing temperature and relative humidity. On the other hand, the minimum seasonal concentrations of sulfur dioxide was 16.99 ± 6.26 µg/m^3 recorded during winter months, may be attributed to that SO_2 is highly soluble in water, and followed by autumn months (19.86 ±10.43 µg/m^3). However, the summer/winter ratio of SO_2 found in this study was 3. The seasonal variation of SO_2 concentration seems to be high dependent upon meteorological condition, the relatively low wind speeds and stable condition during summer months cause the accumulation of SO_2 which is chiefly emitted from motor vehicles. Meanwhile, rainfall during winter months may play a role in decreasing SO_2 concentration as SO_2 is highly soluble in water. This is in agreement with Shakour (1992) who recorded that the average SO_2 levels at new residential areas in Cairo City vary from 13.28 to 19.10 µg/m^3 over the four seasons, with the highest concentrations recorded in summer and autumn. This finding is also, in agreement with Ingle *et al.* (2005) who observed that during the summer season the concentration of oxides of sulfur, in Jalgaon City-India, are very high.

Average NO_2 levels varied from 19.90 to 126.16 µg/m^3 over the four seasons, with the highest concentrations recorded in summer (126.16±9.02 µg/m^3) and followed by spring (95.91 ± 4.52 µg/m^3). The temperature and humidity show a significant association with NO_2 in all the investigated sites (Table 2). The highest concentrations of (NO_2) recorded in summer. On the other hand, the minimum seasonal concentrations of nitrogen dioxide were 19.90 ± 6.31 µg/m^3 recorded during winter months followed by autumn months, 24.14 ± 8.38 µg/m^3. High temperature and calm winds characterize summer season resulting in fast oxidation of NO and accumulation of NO_2. The summer/winter ratio of NO_2 found in this study was 2.5. This finding is in agreement with Bell and Ashenden (1997) who documented that summer roadside concentrations were 7-30% higher than those in winter. Furthermore, Artíñano *et al.* (2004) observed that in Madrid City-Spain, NO_2 exhibit a different seasonal behavior, associated with its photochemical nature. Obviously, variation in NO_2 production by the atmospheric chemical reactions plays a substantial role in the seasonal changes observed in the investigated roads. This may be due to the direct oxidation of NO to NO_2, which may be enhanced by weather conditions during summer months giving rise in the NO_2 levels. Hueglin *et al.* (2006) recorded that besides by meteorology, the quarterly NO_2 concentrations from the traffic sector are influenced by the higher traffic density during summer and by secondary NO_2 formation via reaction of NO with O_3. Consequently, NO_2 contributes significantly to the total NO_2 during the warmer seasons when O_3 concentrations are high.

Average O_3 levels varied from 33.06 to 1384.84 µg/m^3 over the four seasons, the temperature and humidity show a significant association with O_3 in all the investigated sites (Table 2). The highest concentration recorded in summer (1384.84 ± 33.06 µg/m^3) and followed by spring (1000.42 ± 14.06 µg/m^3). Jaffe *et al.* (1996) suggested that O_3 production is known to be a strong function of temperature due to a variety of factors (increased reaction rates, increased solar insolation), reduced wind speeds, etc. On the other hand, the minimum seasonal concentrations of O_3 (33.06 ± 7.13 µg/m^3) recorded during winter months followed by autumn months, 50.03 ± 17.18 µg/m^3. These results may be

attributed that, rain fall during winter months may play a role in decreasing O_3 concentration as O_3 is highly soluble in water. The summer/winter ratio of O_3 found in this study is 6. The meteorological conditions such as high temperature, clear skies and high solar radiation intensity are very important factors affecting the photochemical formation of ozone. Braniš (2009) suggested also that annual pattern of O_3 shows highest values in summer in Prague, the capital city of the Czech Republic.

However, Gariazzo *et al.* (2007) reported that the meteorological conditions in the city of Rome are responsible for the occurrence of high ozone concentrations both during the summer and during the winter seasons. During the summer, solar heating gives rise to the photochemical production of pollutants (e.g. O_3, Sulfate, etc.), while during the winter persistent high-pressure systems, associated with very weak pressure gradients and ground temperature inversion, determine conditions enhancing pollutants accumulation in the lower layers. In addition, Mittal *et al.* (2007) documented that there is substantial temporal and spatial variation in the ozone concentrations due to different meteorological conditions and topography.

Average NH_3 levels varied from 8.96 to 60.04 $\mu g/m^3$ during the four seasons, the temperature and humidity show a significant association with NH_3 in all the investigated sites. The highest concentration recorded in summer (60.04 ± 18.38 $\mu g/m^3$) and followed by spring (36.48 ± 4.11 $\mu g/m^3$). On the other hand, the minimum seasonal concentrations of NH_3 over the majority of recorded roads was 9.37 ±3.60 $\mu g/m^3$ recorded during winter months followed by autumn months, 8.96 ± 1.79 $\mu g/m^3$. The summer to winter ratio of ammonia concentration through the period of investigation was 3. These results are confirmed with Shakour *et al.* (1998) who reported that the temperature is the major factor influencing the level of atmospheric ammonia, beside the wind speed and rainfall. Moreover, Perrino *et al.* (2002) reported that the higher ammonia values at the traffic station indicate the existence of an additional local NH_3 source. NH_3 concentration level, in fact, not only is dependent on the traffic emission flux and on the mixing properties of the boundary layer, also it depends on ambient temperature and relative humidity.

Actually, there are many factors, which affect the seasonal concentrations of SO_2 in the City. These results may be because Damietta City has a climate of Mediterranean Sea area and that winter and maximum rainfall, variable wind directions and relatively low atmospheric temperature characterize spring months. In addition to the high wind speed during the two seasons (winter and spring) which may cause the dispersion of atmospheric SO_2.

Assessment of Traffic Gaseous Pollutants over the Different Sites

Table (3) shows the association between the different gases detected in this study from February 2008 to January 2009.

Sulfur dioxide (SO_2) has a significant association with nitrogen dioxide for high density of motor vehicles (Site 1), whereas, nitrogen dioxide (NO_2) has shown a significant correlation with (O_3) and (NH_3). These results confirmed by the fact that the major source of SO_2 was diesel vehicles where as gasoline engine is the major source of NO_2. D'Angiola *et al.* (2010) stated that together, diesel light and heavy-duty vehicles were responsible for almost 80% of SO_2 emissions and 55% of NO_x emissions. Moreover, ozone has a significant association with SO_2 at site 1. Ozone and nitrogen dioxide were having a significant association for all the collected samples and this is attributed that the major sources at these locations are motor vehicles. This is very clear from the high correlation coefficient, which has been found to hold (NO_2) and (O_3) and (NH_3) for all the investigated sites. Furthermore, this is confirmed by a correlation coefficient of ($r = 0.92$) between NO_2 and O_3 and of ($r = 0.79$) between NO_2 and NH_3.

The maximum concentrations of sulfur dioxide and nitrogen dioxide recorded in many streets in Damietta City can be attributed to the use of diesel fuel which represents 4.49 % in motorcycles, 3.13 % in passenger cars, 2.20 % in vans, 0.08 % in buses and 0.02 % in taxi. On the other hand, gasoline fuel represents 0.05 % in passenger cars, 0.02 % in buses, 0.79 % in vans and 0.02 % in taxi. In addition, natural gas is used as fuel for motor vehicles since 2008 in Damietta City and represents 0.01 % in passenger cars and taxi.

Table (2): Seasonal Mean Concentrations of Temp. (°C), R. H. (%) and Gases as µg/m^3 in the Atmosphere of Investigated Sites.

Season \ Site		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Winter	Temp.	15.1	15.1	15.0	14.8	15.5	13.6	14.5
	Humidity	56.83	55.17	50.60	56.97	57.23	58.74	57.27
	SO_2	35.32	34.27	27.69	26.15	34.84	16.99	21.68
	NO_2	56.51	48.82	38.42	44.91	38.81	26.16	19.9
	O_3	156.73	168.46	168.63	130.93	139.73	33.06	41.54
	NH_3	12.32	12.48	15.18	15.99	13.45	9.37	13.97
Spring	Temp.	36.4	36.2	36.4	34.2	36.3	36.5	37.1
	Humidity	58.03	52.93	54.97	57.93	55.60	66.43	65.73
	SO_2	106.14	108.01	74.95	56.36	98.91	37.12	46.83
	NO_2	68.57	89.52	95.91	73.37	90.68	30.35	32.45
	O_3	851.96	1000.42	892.32	786.34	778.37	45.76	56.85
	NH_3	36.48	34.28	27.76	26.60	26.73	21.13	24.88
Summer	Temp.	35.8	36.4	37.1	35.3	36.3	35.5	36.9
	Humidity	62.40	63.27	59.77	62.27	61.43	63.75	67.17
	SO_2	122.62	122.86	101.51	86.89	95.91	27.66	35.85
	NO_2	116.8	126.16	109.51	111.98	108.62	44.3	41.7
	O_3	1122.56	1384.84	1209.87	858.16	1052.99	65.25	68.36
	NH_3	46.78	48.12	40.39	60.04	51.78	23.59	32.09
Autumn	Temp.	20.7	21.8	23.1	20.6	20.9	22.0	23.0
	Humidity	59.80	59.00	57.20	58.07	58.57	58.12	58.74
	SO_2	45.07	36.63	32.16	37.11	30.60	19.86	20.67
	NO_2	35.9	73.08	54.49	55.48	27.24	24.15	24.14
	O_3	283.21	268.42	252.99	194.55	233.41	50.03	52.22
	NH_3	10.31	9.78	14.97	15.02	16.72	8.96	13.26
Ann. Mean	Temp.	26.28	26.57	27.10	25.51	26.58	26.07	27.08
	Humidity	59.27	57.59	55.63	58.81	58.21	61.76	64.23
	SO_2	77.29	75.44	59.08	51.63	65.07	25.41	31.26
	NO_2	69.45	84.40	74.58	71.44	66.34	31.24	29.55
	O_3	603.62	705.54	630.95	492.50	551.13	48.53	54.74
	NH_3	26.47	26.17	24.58	29.41	27.17	15.76	21.05

Obviously, it has been shown that traffic emissions can be affected by many factors as; that related to the classification of the vehicle types according to the type of fuel, traffic numbers and percentage concentration of traffic numbers. Damietta City is considered as non-heavy industrial area, as there are no heavy industry or power generation plants although many furniture work-shops scattered in the city. Therefore, it is clearly that traffic and local sources of human activities are the main sources of gases (SO_2, NO_2, O_3 and NH_3) recorded in the city atmosphere. In addition, those meteorological parameters play a principal role in distributing the gaseous pollutants in the investigated sites.

5. Recommendations:

The following recommendations suggested improving the air quality Damietta City related to traffic gases emissions:

(i) Reduction in amount of pollutants formed during combustion by suitable modifications in the internal combustion engine.

(ii) Development of exhaust system reactors that will complete the combustion process and change potential pollutants into more acceptable materials.

(iii) Development of alternative fuels that may produce low concentration of pollutants upon combustion.

(iv) Replacement of internal combustion engine with low pollution engines.

(vi) Phasing out of old vehicles.

Table (3): Correlation Coefficients between Gases and Temp. and R. H. over Damietta City.

Site (1)							Site (2)						
	Temp.	R. H	SO_2	NO_2	O_3	NH_3		Temp.	R. H	SO_2	NO_2	O_3	NH_3
Temp.	-	0.38	0.64	0.61	0.84	0.81	Temp.	-	0.28	-0.78	0.63	0.86	0.76
R. H.		-	0.16	0.54	0.46	0.47	R. H.		-	-0.32	0.53	0.23	0.09
SO_2			-	0.35	0.57	0.59	SO_2			-	-0.79	-0.89	-0.81
NO_2				-	0.77	0.73	NO_2				-	0.79	0.76
O_3					-	0.96	O_3					-	0.90
NH_3						-	NH_3						-
Site (3)							Site (4)						
	Temp.	R. H	SO_2	NO_2	O_3	NH_3		Temp.	R. H	SO_2	NO_2	O_3	NH_3
Temp.	-	0.33	-0.71	0.85	0.85	0.72	Temp.	-	0.27	-0.68	0.76	0.92	0.66
R. H.		-	-0.59	0.49	0.43	0.13	R. H.		-	-0.40	0.52	0.37	0.38
SO_2			-	-0.64	-0.62	-0.57	SO_2			-	-0.58	-0.61	-0.42
NO_2				-	0.88	0.72	NO_2				-	0.77	0.79
O_3					-	0.95	O_3					-	0.69
NH_3							NH_3						-
Site (5)							Site (6)						
	Temp.	R. H	SO_2	NO_2	O_3	NH_3		Temp.	R. H	SO_2	NO_2	O_3	NH_3
Temp.	-	0.04	-0.66	0.85	0.79	0.55	Temp.	-	0.81	0.68	0.52	0.60	0.75
R. H.		-	-0.15	0.29	0.32	0.45	R. H.		-	0.57	0.18	0.44	0.68
SO_2			-	-0.56	-0.67	-0.49	SO_2			-	0.35	0.57	0.84
NO_2				-	0.92	0.67	NO_2				-	0.65	0.57
O_3					-	0.63	O_3					-	0.61
NH_3						-	NH_3						-
Site (7)													
	Temp.	R. H	SO_2	NO_2	O_3	NH_3							
Temp.	-	0.94	0.53	0.72	0.64	0.74							
R. H.		-	0.36	0.69	0.65	0.69							
SO_2			-	0.20	0.18	0.72							
NO_2				-	0.65	0.57							
O_3					-	0.61							
NH_3						-							

The values in bold indicate a significant correlation between those two parameters.
Temp. = Temperature, R. H. = Relative Humidity.

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