Estimation of Seasonal Variation of Air Pollutants, No_2, So_2, Pm_{10} and Land Surface Temperature (Lst) of Nile Delta Region

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Abstract: Climate change can be driven by change in the atmospheric concentrations of a number of radiatively active gases and aerosols, human activities have affected concentrations, distributions and life cycles of these gases. Therefore, the objective of this study to estimate the impact of air pollutants (e. g. NO_2, SO_2, and PM_{10}) on Land Surface Temperature (LST) at the Nile Delta region**.** In the present study, twenty sites located at the southeast of Nile Delta were selected. A total of twenty eight Landsat ETM+ images bands 6, of path (176) and row (39), acquired during the years from 2000 to 2009; are employed in the current study. The images were processed in ENVI 4.7 software to estimate the mean of LST for the warm and cold seasons over the study sites. The available analytical data of air pollutants (e. g. SO_2, NO_2, and PM_{10}) have been collected from the monthly reports of Environmental Information and Monitoring Program published during 2006 year. The correlation between the LST and pollutants was worked out using SPSS software. The results indicate that the correlation between NO_2, PM_{10} and LST is positive. Whereas, the results of SO_2 show that the correlation is negative.

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1. Introduction:

Naturally occurring greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Several classes of halogenated substances that contain fluorine, chlorine, or bromine are also greenhouse gases, but they are, for the most part, solely a product of industrial activities.

The primary climate change effects of nitrogen oxides (NO_x) are indirect and result from their role in promoting the formation of ozone in the troposphere and, to a lesser degree, lower stratosphere, where it has positive radiative forcing effects. Additionally, NO_x emissions from aircraft are also likely to decrease methane concentrations, thus having a negative radiative forcing effect (**IPCC, 1999**).

Sulfur compounds (sulfur dioxide, hydrogen sulfide, and dimethyl sulphide) contribute to the formation of sulfate aerosols with a negative radiative forcing (climate cooling). Industrial sources dominate, despite declines in some regions due to controls and legislation (**Rodhe, 1999; Penner *et al*., 2001**). Ecosystems are a sink for about 30% of SO_2 emissions and for sulfate aerosols. Dimethyl sulfide, emitted by marine phytoplankton when they die or are eaten, contributes to cloud formation.

Particles, especially those containing sulfate, exert a direct effect by scattering incoming solar radiation back to space, thus providing a cooling effect. However, black carbon in particles absorbs solar radiation and consequently warms the atmosphere **(Grambsch, 2002).** Model perturbation studies find that the effect of temperature on PM depends on the PM component. Sulfate concentrations increase with temperature, due to faster SO_2 oxidation (higher rate constants and higher oxidant concentrations). In contrast, nitrate and organic semi-volatile components shift from the particle phase to the gas phase with increasing temperature. Model sensitivity studies indicate large decreases of nitrate PM with increasing temperature, dominating the overall effect on PM concentrations in regions where nitrate is a relatively large component. Other studies find much weaker sensitivities of organic PM to temperature, reflecting the weaker temperature dependences of the gas-particle equilibrium constants (**Jacob *et al*., 2009).**

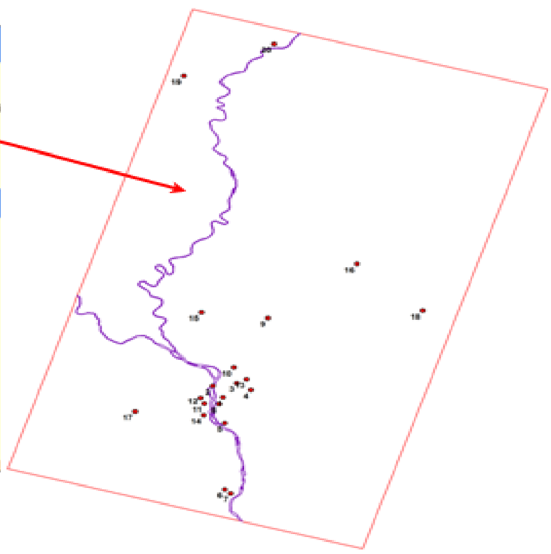
Geographic Information System (GIS) is a powerful tool that is being used to analyze satellite images, aerial photographs and hard copy maps to derive information through producing thematic maps and creating solutions for a specific problem by using definite criteria. The GIS is very useful for analysis and creation of models that, incorporates the relations between the different features on the surface and its effect on the environment. It can be used to perform a number of fundamental spatial analysis operations. Its major advantage is that, it allows the user to identify the spatial relationships between various map features. More precisely, overlay techniques allow synthesizing of different map layers, based on a database where the information is stored as a whole. Comparisons, as well as further analyses, among and between both variables and layers can be easily performed (**ESRI, 1994).**

The present study aims to investigate the effect of air pollutants (NO_2, SO_2 and PM_{10}) on land surface temperature in the study sites. Therefore, the air pollutants concentration values has been correlated with the relative land surface temperature, while SPSS software, remote sensing and Geographic Information System (GIS) techniques were used for giving quantitative information on the influence of air pollutants concentrations on temperature of the study area.

METHODOLOGY

The Study Area

The Nile Delta is sometimes divided into West and East sections, with the Nile dividing into two main distributaries, the Damietta and the Rosetta, flowing into Mediterranean at port cities with the same name. In the past, the delta had several distributaries, but these have been lost due to flood control, silting and changing relief. One such defunct distributary is Wadi Tumilat. The Suez Canal runs to the east of the delta, entering the coastal Lake Manzala in the north-east of the Delta, adding to three other coastal lakes or lagoons: Lake Burullus, Lake Idku and Lake Maryut are in the north-west. It is considered to be an "arcuate" delta (arc-shaped), and resembles a triangle or lotus flower when seen from above. The outer edges of the delta are eroding and some coastal lagoons have seen increasing salinity levels as their connection to Mediterranean Sea increases. Since the delta no longer receives an annual supply of nutrients and sediments from upstream, the soils of the floodplains have become poorer and large amounts of fertilizers are now used. Topsoil in the delta can be as much as 70 feet in depth, (Ahmad, 1995) (Map. 1). The Nile Delta has a Mediterranean climate, characterized by little rainfall. Only 100 to 200 mm of rain falls on the delta area during an average year and most of this falls in the winter months. The delta experiences its hottest temperatures in July and August, averaging 30°C, with a maximum of around 48°C. Winter temperatures are normally in the range of 5°C to 10°C. The Nile Delta region becomes quite humid during the summer months.



Map (1) Location of the study area **Figure (1) Distribution of the studied sites over investigated area**

1- Al-Qulaly (Site 1),
2- Al-Jomhoria (Site 2),
3- Al-Abbassiya (Site 3),
4- Nasr City (Site 4),
5- Al-Maadi (Site 5),
6- Tebbin (Site 6),
7- South Tebbin (Site 7),
8- Fum Al-Khalij (Site 8),
9-Abo-Za'bal (Site 9),
10-Shubra Al-khima (Site 10),
11-Giza, Agricultural UV (Site 11),
12-Giza, University City (Site 12),
13- Heliopolis (Site 13),
14- Muhandissen (Site 14),
15-Qaha (Site 15),
16-Belbees (Site 16),
17- 6th of October (Site 17),
18-10th of Ramadan (Site 18),
19- Mahalla (Site 19),
20- Mansoura (Site 20).

Sampling Strategy and Analytical Protocol
Air Pollutants (SO_2, NO_2, and PM_{10})

Twenty investigated sites selected to cover great portion of south and east of the Nile Delta region. Figure (1) presents the distribution of the studied sites over the area under investigation for source environmental information and monitoring program published during 2006 year.

Samples were identified from studied sites using Global Positioning System (GPS) (Fig. 1), as follow: A total of nine stations are located in Cairo governorate (El-Qulaly (Site 1), Al-Jomhoria (Site 2), Al-Abbassiya (Site 3), Nasr City (Site4), Al-Maadi (Site 5), Tebbin (Site 6), Tebbin South (Site 7), Fum El-khalij (Site 8), Heliopolis (Site 13)), three sites in Qalubya (Abo Za'bal (Site 9), Qaha (Site 15), Shubra Elkhima (Site 10)), two sites in Sharkia, Belbees (Site 16), 10^{th} of Ramadan(Site 18)), one site in Dakahlia (Mansoura) (Site 20), one site in Gharbia (Mahalla) (Site 19) and four sites in Giza, Muhandissen (Site 14), Agriculture university (Site11), University city (Site 12) and 6^{th} of October (Site 17)). After categorizing the data in different data subsets, an assessment of the relationship between temperature and air pollutants concentration was made using Excel spreadsheets and subsequently data analysis completed using SPSS statistical tool; scatter diagrams and simple correlations were also performed.

Image Processing

A total number of twenty eight Landsat ETM+ images bands 6.1, of path 176 and row 39, acquired are employed in the current study during the period from 2000 and 2009. The images are processed using ENVI 4.7 software to demonstrate the mean LST in warm and cold seasons over the Nile Delta Region.

Estimation of land surface temperature (LST)

The DNs is converting to radiance values using the bias and gain values obtained from the image header file.

$$CVR= G *(CVDN) + B \qquad \text{(eq 1)}$$

Where: CVR is the cell value as radiance, CVDN is the cell value digital number, G is the gain and B is the bias (or offset), (NASA, 2002).

The radiance data is converting to degrees in Celsius

$$T = [K2 / LN (K1 / CVR + 1)] – 273 \qquad \text{(eq 2)}$$

Where: T is degrees in Celsius, CVR is the cell value as radiance, K1 and K2 are two constant with values of 666.09 and 1282.71 respectively (NASA, 2002).

Statistical Analysis

The data of different data subsets were categorizing. Then, an assessment of pollutants influence on the land surface temperature was completed using excel spreadsheets and subsequently data analysis completed using SPSS statistical software tool. Scatter diagrams and simple correlations were performed to assess the relation between temperature and ambient concentration of air pollutants in the study area.

3. Results and Discussion

Estimation of (LST) at Nile Delta Region during 2000 to2009, Year

In this study, the monthly temperature change values of the twenty stations on the southeast Nile Delta estimated during study period are illustrated in table (1) and fig. (1). As a preliminary study for estimated LST over the study area, two months (February and July) were represented.

The land surface temperature (LST) values in an urban center, El-Qulaly station (Site 1) during the winter months (December, January, February and March) were 14.71, 14.85, 16.05 and 20.63°C, respectively, while in summer months (June, July, August and September) were recorded 33.52, 31.63, 31.46 and 31.29°C, respectively. However, LST values of Al-Jomhoria station (Site 2) street canyon during the winter months were 16.05, 15.59, 17.82 and 22.33°C, respectively, while in summer months were recorded 33.63, 30.83, 32.18 and 32.33°C, respectively.

Whereas, it is noticed that in urban /residential area, Al-Abbassiya (Site 3), Nasr city (Site 4) and Al-Maadi (Site 5) during the winter months, temperature values were (15.16, 16.16, 17.16 and 21.91°C), (16.05, 16.44, 17.81 and 22.32°C) and (14.25, 14.70, 16.48 and 20.84°C), respectively, while in summer months were recorded (35.16, 31.90, 32.09 and 32.28°C), (34.21, 31.75, 32.09 and 32.26°C) and (32.57, 29.71, 30.62 and 30.11°C), respectively. The temperature values of industrial areas, Tebbin station (Site 6), and South Tebbin (Site 7), during the winter season months were (14.25, 18.69, 18.88 and 20.85°C) and (14.25, 14.57, 15.83 and 21.06°C), respectively, while in summer months were recorded (29.81, 26.82, 31.33 and 30.31°C) and (34.02, 31.36 31.39 and 30.64°C), respectively.

However, it is noticed that during the winter months temperature values of Fum El-khalij, road side/urban (Site 8) area were 14.71, 14.85, 16.49 and 21.27°C, respectively, while in summer months were recorded (34.32,32, 32.19 and 31.30°C), respectively.

For industrial/residential area, Abo Za'bal station (Site 9), during the winter months temperature values were 15.16, 15.60, 15.60 and 20.42°C, respectively, while in summer months were recorded 36.30, 31.08, 28.83 and 29.91°C, respectively. However, in industrial area Shubra Elkhima (Site 10), during the winter months temperature values were 14.71, 13.79, 16.05 and 21.27°C, respectively, while in summer months were recorded 34.32, 30.98, 31.69 and 31.49°C, respectively.

In residential/urban area, Giza (Agriculture University) (Site 11), Giza (University City) (Site 12), Heliopolis station (Site 13) and Muhandissen station (Site 14), during the winter months (December, January, February and March) temperature values were (16.05, 14.64, 17.15 and 22.12°C), (15.16, 14.85, 16.71 and 21.27°C), (15.60, 14.01, 17.89 and 22.12°C), (15.60, 15.15, 16.71 and 21.48°C), respectively. While, in summer months (June, July, August and September) were recorded (34.59, 32.74, 32.63 and 32.58°C), (34.38, 31.45, 31.46 and 31.49°C), (34.15, 29.96, 30.63 and 30.11°C) and (34.47, 31.94, 32.12 and 31.69°C), respectively.

In remote area, Qaha station (Site 15) and Belbees station (Site 16), during the winter months temperature values were (16.05, 12.24, 16.05 and 22.75°C) and (15.60, 15.94, 16.27 and 19.99°C), respectively, while in summer months were recorded (33.09, 30.96, 29.69 and 32°C) and (33.83, 27.71, 27.29 and 28.40°C), respectively.

However, residential/industrial area, 6th of October (Site 17) and 10th of Ramadan (Site 18), and temperature values during the winter months were (16.05, 16.6, 17.15 and 22.97°C) and (16.94, 18.10, 18.48 and 24.43°C), respectively. While in summer months were recorded (32.61, 31.73, 32.58 and 32°C) and (37.44, 34.84, 36.50 and 36.31°C), respectively

For residential /industrial area, Mahalla station (Site 19) and Mansoura station (Site 20), and the temperature values during the winter months were (13.80, 14.81, 14.48 and 20.40°C) and (14.25, 14.55, 14.26 and 17.58°C), respectively, while in summer months were recorded (31.20, 30.44, 30.7 and 30.96°C) and (27.09, 25.14, 24.63 and 24.84°C), respectively.

Estimation of Seasonal Variation of Air Pollutants (NO_2, SO_2, and PM_{10}) at Nile Delta Region.

Table (1): Monthly Mean Land Surface Temperature Estimated from Landsat ETM+ Thermal Band for Investigated Stations, over Nile Delta Region in year, 2000- 2009.

Station ID	Location	Temperature (°C)											
		Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	El-Qulaly	14.85	16.05	20.63	25.82	29.51	33.52	31.63	31.46	31.29	27.64	19.70	14.71
2	Al-Jomhoria	15.59	17.82	22.33	26.86	29.91	33.63	30.83	32.18	32.33	28.53	21.56	16.05
3	Al-Abbassiya	16.16	17.16	21.91	27.05	30.71	35.16	31.90	32.09	32.28	28.46	20.70	15.16
4	Nasr City	16.44	17.81	22.32	27.67	30.71	34.21	31.75	32.66	32.26	28.67	21.13	16.05
5	Al-Maadi	14.70	16.48	20.84	25.83	29.12	32.57	29.71	30.62	30.11	26.66	20.16	14.25
6	Tebbin	18.69	18.88	20.85	24.78	28.72	29.81	26.82	31.33	30.31	27.81	19.98	14.25
7	Tebbin South	14.57	15.83	21.06	26.03	29.51	34.02	31.36	31.39	30.64	27.19	19.12	14.25
8	Fum El-khalij	14.85	16.49	21.27	26.23	29.91	34.32	32.00	32.19	31.30	27.87	20.40	14.71
9	Abo Za'bal	15.60	15.60	20.42	26.40	31.10	36.30	31.08	28.83	29.91	27.67	21.41	15.16
10	Shubra Elkhima	13.79	16.05	21.27	26.24	29.51	34.32	30.98	31.69	31.49	27.24	20.13	14.71
11	Giza (Agr. Unv.)	14.64	17.15	22.12	26.45	29.51	34.59	32.74	32.63	32.58	28.60	21.40	16.05
12	Giza (Unv. city)	14.85	16.71	21.27	25.63	28.72	34.38	31.45	31.47	31.49	28.13	20.98	15.16
13	Heliopolis	14.01	17.89	22.12	26.26	28.72	34.15	29.96	30.63	30.11	27.28	20.79	15.60
14	Muhandissen	15.15	16.71	21.48	26.64	30.31	34.47	31.94	32.12	31.69	28.07	21.08	15.60
15	Qaha	12.24	16.05	22.75	27.08	29.51	33.09	30.96	29.69	32.00	28.38	21.56	16.05
16	Belbees	15.94	16.27	19.99	26.39	31.49	33.83	27.71	27.29	28.40	27.18	21.56	15.60
17	6th of October	16.60	17.15	22.97	25.84	28.72	32.61	31.73	32.58	32.08	28.07	22.11	16.05
18	10th of Ramadan	18.10	18.48	24.43	29.26	33.05	37.44	34.84	36.50	36.31	31.61	24.20	16.94
19	Mahalla	14.81	14.48	20.40	26.63	30.71	31.20	30.44	30.7	30.96	26.88	20.85	13.80
20	Mansoura	14.55	14.26	17.58	26.69	33.83	27.09	25.14	24.63	24.84	23.81	21.68	14.25

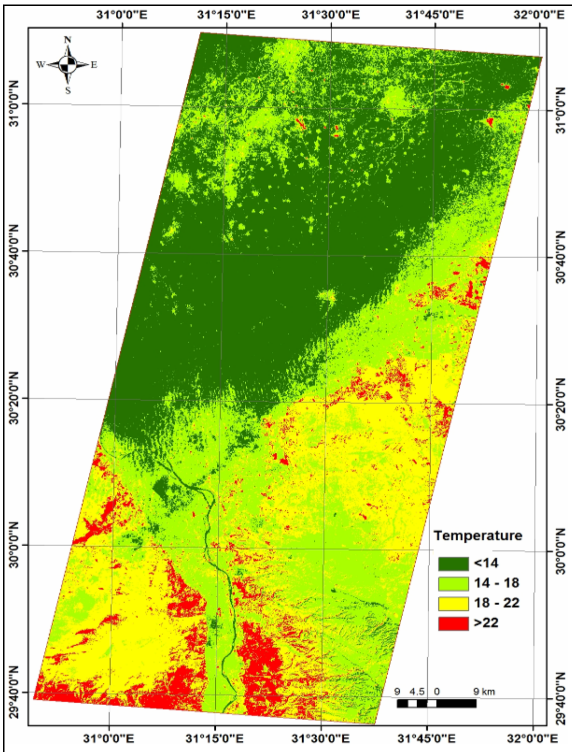


Figure (2) spatial distribution of the estimated mean land surface temperature over the study area in February from 2000 to 2009

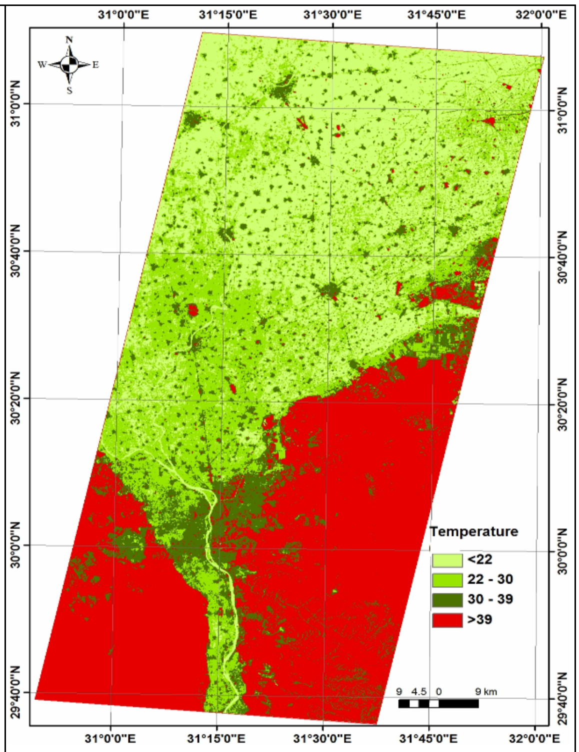


Figure (3) spatial distribution of the estimated mean land surface temperature over the study area in July from 2000 to 2009

Twenty measurement sites selected to cover great portion of south and east of the Nile Delta region (tables 1, 2, 3 and 4). These sites were part of the EIMP/EEAA air quality monitoring program. The available data indicate that, in an urban center, El-Qulaly station (Site 1) the maximum concentration of SO_2 was 206.59 ppm, in July and temperature value was 31.63°C. While the minimum concentration of SO_2 was 72.53 ppm, in September and the corresponding temperature was 31.29°C. However, the maximum concentration of NO_2 was 96.39 ppm, in February and the corresponding temperature value was 16.05°C, while the minimum concentration of NO_2 was 68.80 ppm, in August and the corresponding temperature was 31.46°C. It is noticed that the maximum concentration of PM_{10} was 203.26µg/m^3, in November and the corresponding temperature value was 19.70°C, while the minimum concentration of PM_{10} was 4.23 µg/m^3, in April, the corresponding temperature was 25.82°C.

In the canyon street Al-Jomhoria station (Site 2) the maximum concentration of SO_2 was 155.66 ppm, in February and the corresponding temperature value was 17.82°C, while the minimum concentration was 24.53ppm, in September and the corresponding temperature was 32.33°C. Whereas, the maximum concentration of NO_2 was 101.82 ppm, in May and the corresponding temperature value was 29.91°C, while the minimum concentration was 37.96 ppm, in October and the corresponding temperature was 28.53°C. However, the maximum concentration of PM_{10} was 255.30µg/m^3, in March and the corresponding temperature value was 22.33°C, while the minimum concentration of PM_{10} recorded was 97.86µg/m^3, in May, the corresponding temperature was 29.91°C.

Whereas, it is noticed that in urban/residential area, Al-Abbassiya (Site 3), Nasr City (Site 4) and Al-Maadi (Site 5), the maximum concentrations of SO_2 were 51.97, 19.36 and 41.01ppm, in November, January and December, respectively, and the corresponding temperatures were 20.70, 16.44 and 14.25°C, respectively. While, the minimum concentrations of SO_2 were 11.25, 4.27 and 18.07 ppm, in August, September and January, respectively, and the corresponding temperatures were (32.09, 32.26 and 14.70°C). In Site (4) and Site (5), the maximum concentrations of NO_2 were 79 and 52 ppm, in November and December, respectively, and the corresponding temperatures were 21.13 and 14.25°C. While, the minimum concentrations of NO_2 were 50.66 and 38.54 ppm, in September and July, the corresponding temperatures were 21.13 and 29.71°C, respectively.

In industrial areas, Tebbin station (Site 6), the maximum concentrations of SO_2 and NO_2 were 36.13 and 39.76 ppm, in January and February, the corresponding temperatures were 18.69 and 18.88 °C, respectively. While the minimum concentrations of SO_2 and NO_2 were 9.93 and 24.85 ppm, in December and May, the corresponding temperatures were 14.25 and 27.19 °C, respectively. Whereas, the maximum concentration of PM_{10} was 213.17µg/m^{3}in November and the corresponding temperature was 19.98 °C, while the minimum concentration of PM_{10} was 30.80µg/m^3, in March and the corresponding temperature was 20.85 °C, respectively.

In South of Tebbin (Site 7), the maximum concentration of SO_2 was 378.67 ppm, in September and the corresponding temperature was 30.64°C. While the minimum concentration of SO_2 was 1 ppm, in October and the corresponding temperature was 27.19°C.

However, it is noticed that in Fum El-khalij, road side/urban (Site 8) the maximum concentration values of SO_2 and NO_2 were 57.51 and 73.73 ppm, in April and September, respectively, and the corresponding temperatures were 26.23 and 31.30 °C, respectively. While the minimum concentration of SO_2 and NO_2 were 17.07, and 51.92 ppm, in September and March, respectively, the corresponding temperatures were 31.30 and 21.27 °C, respectively. Whereas, the maximum concentration value of PM_{10} was 235.84µg/m^3 in November and the corresponding temperatures was 20.40°C. While, the minimum concentration of PM_{10} was 66.43µg/m^3, in November and the corresponding temperatures was 29.91°C.

For industrial area, Shubra Elkhima station (Site 10), the maximum concentration of SO_2 and NO_2 were 99.13 and 77 ppm, in June and November, respectively, the corresponding temperature values were 34.32 and 20.13 °C, respectively, while the minimum concentration of SO_2 and NO_2 were 54.39 and 22.60 ppm, in December and March, respectively, the corresponding temperature values were 14.71, 21.27 and 26.24 °C, respectively. However, the maximum concentration of PM_{10} was 200.56 µg/m^3, in December and the corresponding temperature values was 14.71 °C, while the minimum concentration of PM_{10} was 82.48 µg/m^3, in April and the corresponding temperature values was 26.24 °C,

In residential / urban area, Giza (agriculture university) (Site 11), Giza (university city) (Site 12), the maximum concentrations of SO_2 were 47 and 39.12ppm, in June and May, respectively, the corresponding temperature values were 34.59, and 28.72°C, respectively, while the minimum concentrations of SO_2 were 15.48 and 14.48 ppm, in January, respectively, and the corresponding temperature values were 14.64, and 14.85 °C, respectively.

In remote area, Qaha station (Site 15) the maximum concentration of PM_{10} was 202µg/m^3, in October and the corresponding temperature value was 28.38°C, while the minimum concentration of PM_{10} recorded was 17.88µg/m^3, in March and the corresponding temperature was 22.75°C.

However, residential / industrial area, 6th of October (Site 17) and 10th of Ramadan (Site 18), the maximum concentrations of SO_2 were 10.12 and 9.51ppm, in April and November, respectively, the corresponding temperature values were 25.84, and 24.20 °C, respectively, while the minimum concentrations of SO_2 were 1.73 and 0.8ppm, in December, respectively, and the corresponding temperature values were 16.05, and 16.94 °C, respectively.

For residential / industrial area, Mansoura Station (Site 20), the maximum concentration of SO_2 was 13.38 ppm, in December and the corresponding temperature value was 14.25°C, while the minimum concentration of SO_2 was 6.74 ppm, in July, the corresponding temperature was 25.14°C.While, the maximum concentration of NO_2 was 28.00 ppm, in December and the corresponding temperature value was 14.25°C, while the minimum concentration of NO_2 recorded was 11.21 ppm, in October, the corresponding temperature was 23.81°C.

Table (2): Monthly Mean Concentrations of Gases (SO_2) for Investigated Stations over Nile Delta Region in year, 2006.

Location	Sulpher dioxide concentration (SO_2)													
	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Min.
El-Qulaly	91.61	97.35	113.04	152.84	151.47	186.01	206.59	76.22	72.53	81.42	93.74	100.58	206.59	72.53
Al-Jomhoria	75.48	155.66	32.90	43.14	42.63	59.48	41.92	32.34	24.53	60.33	81.90	75.11	155.66	24.53
Al-Abbassiya	45.80	43.00	43.47	45.27	34.61	24.49	14.22	11.25	21.33	35.80	51.97	45.32	51.97	11.25
Nasr City	19.36	11.57	12.42	12.78	12.04	8.00	-	8.44	4.27	7.60	15.31	14.24	19.36	4.27
Al-Maadi	18.07	19.76	21.74	20.77	22.07	-	35.18	28.97	28.80	32.86	35.50	41.01	41.01	18.07
Tebbin	36.13	22.65	22.36	13.85	15.05	-	11.23	11.53	17.07	-	21.35	9.93	36.13	9.93
Tebbin South	4.52	8.19	-	-	-	-	-	20.53	378.67	1.00	6.26	9.50	378.67	1
Fum El-khalij	50.32	49.64	55.90	57.51	52.16	28.00	22.46	31.22	17.07	28.94	48.96	-	57.51	17.07
Shubra Elkhima	77.42	80.00	83.85	-	89.78	99.13	85.33	86.91	-	-	-	54.39	99.13	54.39
Giza (Agri. Univ.)	15.48	30.36	38.50	-	39.12	47.00	32.19	21.94	17.07	22.56	21.35	25.47	47	15.48
Giza (Univ. city)	15.48	30.36	38.50	-	39.12	-	32.19	21.94	17.07	22.56	21.35	25.47	39.12	15.48
6th of October	3.23	4.34	4.35	10.12	4.51	2.92	3.00	3.38	2.00	2.94	6.50	1.73	10.12	1.73
10th of Ramadan	-	-	-	-	3.51	-	4.49	4.22	2.00	2.45	9.51	0.80	9.51	0.8
Mansoura	-	10.60	7.45	-	-	-	6.74	-	7.47	-	-	13.38	13.38	6.74

Note: (-) mean that data not available

Table (3): Monthly Mean Concentrations of Gases (NO_2) for Investigated Stations over Nile Delta Region in year, 2006.

Location	Nitrogen dioxide (NO_2)													
	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Min.
El-Qulaly	85.92	96.39	79.33	76.68	75.76	77.00	77.08	68.80	73.73	73.12	78.00	70.89	96.39	68.8
Al-Jomhoria	56.40	64.34	52.40	-	101.82	64.00	51.97	54.80	47.90	37.96	-	44.89	101.82	37.96
Nasr City	-	-	-	-	-	-	-	-	50.66	54.52	79.00	67.78	79	50.66
Al-Maadi	-	-	-	-	-	-	38.54	38.76	39.12	38.73	-	52.00	52	38.54
Tebbin	38.40	39.76	34.38	27.39	24.85	-	-	-	-	-	-	-	39.76	24.85
Fum El-khalij	54.00	53.25	51.92	57.10	59.39	-	-	62.49	73.73	55.03	-	-	73.73	51.92
Shubra Elkhima	44.16	36.63	22.60	26.72	28.79	-	28.03	-	-	-	77.00	62.67	77	22.6
Giza (Agriculture University)	62.64	66.27	65.39	71.70	58.79	55.00	51.97	36.88	47.90	43.31	-	54.44	71.7	36.88
6th of October	22.56	19.04	18.27	5.98	7.88	14.00	10.90	22.54	-	-	-	-	22.56	5.98
Mansoura	-	-	-	-	-	-	22.58	-	19.31	11.21	-	28.00	28	11.21

Table (4): Monthly Mean Concentrations of Particulate matter (PM_{10}) for Investigated Stations over Nile Delta Region in year, 2006.

Location	Particulate matter (PM_{10})/ µg/m^3													
	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Max.	Min.
El-Qulaly	112.35	105.72	6.95	4.23	-	-	-	-	-	147.57	203.26	163.65	203.26	4.23
Al-Jomhoria	189.73	239.46	255.30	177.64	97.86	-	-	108.00	-	-	-	-	255.3	97.86
Al-Abbassiya	110.86	99.40	84.44	105.74	101.79	74.00		76.00	93.22	134.00	164.31	143.45	164.31	74
Tebbin	72.92	51.50	30.80	52.87	43.93	-	-	-	126.27	160.20	213.17	180.36	213.17	30.8
Fum El-khalij	117.56	112.05	88.41	99.40	66.43	-	-	-	135.60	173.13	235.84	186.63	235.84	66.43
Shubra Elkhima	159.23	113.86	103.31	82.48	105.71	-	-	-	-	-	-	200.56	200.56	82.48
Qaha	32.73	35.24	17.88	63.44	53.93	-	-	-	-	202.00	179.18	192.90	202	17.88

Correlation between Seasonal Variation of Air Pollutants and Temperature

The correlation in warm season

The obtained data was illustrated that the highest average concentration of SO_2 in warm season of the year 2006 recorded 378.67 ppm at Tebbin South and the corresponding temperature was 30.64^{o}C while the lowest concentration was 2 ppm which noted at 6th of October and the corresponding temperature was 32.08^{o}C. The correlation coefficient between concentration of SO_2 and temperature in warm season of the year 2006 was found to be negative during this season(-0.02325); these observations are in agreement with the results of Wang et al. (2009); IIabaca et al. (1999); Zhao et al. (2011); Ostro et al. (1995); Kan et al. (2003); Guo et al. (2010); Martins et al. (2006) who found that the correlation coefficient between concentration of SO_2 and temperature is negative. Regarding to NO_2 concentration, the obtained data showed that the highest NO_2 in warm season was 77.08 ppm which recorded at Al Qulaly station and the corresponding temperature was 31.63^{o}C while the lowest concentration was 10.90 ppm which noted at 6th of October and the corresponding temperature was 31.73^{o}C. The correlation coefficient between concentration of NO_2 and temperature in warm season was found to be positive during this season (0.5582). This is in agreement with, Wald et al. (1998); Wichmann (2006) who found that the correlation coefficient between concentration of NO_2 and temperature is positive. For the average PM_{10} concentration the data illustrated that the highest average concentration in warm season was 135µg/m^3 which recorded at Fum Al Khalij and the corresponding temperature was 31.30^{o}C while the lowest concentration was 74µg/m^3 which noted at Al Abbassiya station and the corresponding temperature was 35.16^{o}C. The correlation coefficient between concentration of PM_{10} and temperature during this season was found to be positive during this season (0.28995). This is in agreement with, Guo et al. (2010); Cerdeira et al. (2006); Wichmann (2006); Adhikari et al. (2006) who found that the correlation coefficient between concentration of PM_{10} and temperature is positive.

The correlation in cold season

The obtained data show that the highest average concentration of SO_2 in cool season of the year 2006 was 155.66 ppm which recorded at Al-Jomhoria station and the corresponding temperature was 17.82^{o}C while the lowest concentration was 0.8 ppm which noted at 10 of Ramadan and the corresponding temperature was 16.94^{o}C. The correlation coefficient between concentration of SO_2 and temperature in cold season of the year 2006was found to be negative during this season (-0.1695). these results in agreement with, IIabaca et al. (1999); Zhao et al. (2011); Ostro et al. (1995); Kan et al. (2003); Guo et al. (2010); Martins et al. (2006) who found that the correlation coefficient between concentration of SO_2 and temperature is negative. Regarding to NO_2 concentration, the obtained data showed that the highest NO_2 in cool season was 96.39 ppm which recorded at Al Qulaly station and the corresponding temperature was 16.05^{o}C while the lowest concentration was 18.27 ppm which noted at 6th of October and the corresponding temperature was 22.97^{o}C. The correlation coefficient between concentration of NO_2 and temperature in cold season was found to be negative during this season (-0.0219). This is in agreement with, Wang et al. (2009); Martins et al. (2006); Ostro et al. (1995); Cerdeira et al. (2006); Kan et al. (2003); Guo et al. (2010); Zhao et al. (2011), who found that the correlation coefficient between concentration of NO_2 and temperature is negative and weak .For the average PM_{10} concentration the data illustrated that the highest average concentration of PM_{10} in cool season was 255.30µg/m^3 which recorded at Al-Jomhoria station and the corresponding temperature was 22.33^{o}C while the lowest concentration was 6.95µg/m^3 which noted at Al Qulaly station and the corresponding temperature was 20.63^{o}C. The correlation coefficient between concentration of PM_{10}

and temperature during this season was found to be positive during this season (0.2235). This is in agreement with, Guo et al. (2010); Cerdeira et al. (2006); Wichmann (2006); Adhikari (2006) who found that the correlation coefficient between concentration of PM_{10} and temperature is positive.

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