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Air Pollution and its Impact on the Elements of Soil and Plants in Helwan Area

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Abstract

Over the past two decades, the threat of environmental pollution elements has attracted attention as much as the air pollution. Concentrations of many trace elements in the environment have been significantly affected by man's activities.

The present study was made to evaluate the potential effects of ambient air pollutants (SO_2, NO_2, CO and PM10) on *Calotropis procera* and soil in Helwan city. The study also aimed to evaluate the damaging effect of human activities on soil and some plants, where samples would have collected from industrials, traffic and domestic sources in Helwan city. Sampling and measurements were based on the environmental protection agency (EPA) and the American Standard test methods (ASTM). Evaluation of air pollutants (SO_2, NO_2, CO and PM10) was measured by Miran Gas Analyzer and Thermo Dust Meter. It was found that all metals were belonging to very high contamination category at all sites near the factories except iron. the internal parts of the leaf and shoot in the *Calotropis procera* are not affected by concentrations of air pollutants found in Helwan industrial area air or even high concentrations in soil

Keywords: *Calotropis procera* ; Air Pollution; Heavy Metals; Soil; Helwan.

Introduction

Air pollution may be defined as any atmospheric condition in which substances are present at concentrations high enough above their normal ambient levels to produce a measurable effect on man, animals, vegetation, or materials. Substances mean any natural or anthropogenic (man-made) chemical compounds capable of being airborne. They may exist in the atmosphere as gases, liquid droplets, or solid particles **(Brimblecombe *et al.*, 2005).**

Although heavy metals are naturally present in the soil, geologic and anthropogenic activities increase the concentration of these elements to amounts that are harmful to both plants and animals. Some of these activities include mining and smelting of metals, burning of fossil fuels, use of fertilizers and pesticides in agriculture, production of batteries and other metal products in industries, sewage sludge, and municipal waste disposal **(Chauhan and Joshi, 2008).**

Cairo is classified as one of the most polluted cities in the world. Accordingly, monitoring of heavy and toxic elements in ambient air are mandatory. The increase in ambient contamination has become a serious problem to public health. Cement and other industrial activities are often the origin of environmental pollution although they play a vital in creating income, they also impose a heavy burden on the ecological system **(Filipovic, 2012).** Cement bypass dust represents a major pollution problem in Egypt. Around 2.4 million tons per Year are released into the atomosphere. As a result, generally high levels of particular matter are observed in the greater Cairo area and high toxic level are encounterd at the industrailization sites of Helwan and Tebbin south of Cairo. Accordingly, urgent environment protection is required in the great Cairo area to reduce air pollution that have a seriouse impact on human health **(Agardy and Nemerow - 2010).**

There are many studies assessed the impact of air pollution on plant growth and soil in Egypt as **Agardy and Nemerow, (2010)** who stated that the main problems of the environmental pollution in urban and rural Egypt include the disposal of solid and liquid waste, including hazardous materials, air pollution, the purity of the water supply, pests, noise levels, the enduring presence of harmful chemicals originally used as pesticides and fertilizers.

Also, **Yang *et al.*, (1996)** concluded that environmental pollution was increased by increasing the industry development all over the world and especially in Egypt; increment of these pollution caused many hazards for all organisms, even for humans such as carcinogenicity and toxicity. Also, there has been increasing pollution with hydrocarbon compounds, many of these hydrocarbons considered to be a potential health hazard.

Mohamed *et al.*, (2013) studied the impact of heavy metals in the dust fall around Assiut fertilizer factory and they concluded that, Levels of heavy metal were 3.3, 26.5, 22.3, 235.0, 4.5 and 3.8 μg/g for As, Cu, Pb, Zn, Cd and Hg, respectively in the deposited dust fall. Enrichment coefficients of the heavy metals in the dust fall were found to be significant and reached the values 1.8, 0.9, 0.9, 0.7, 0.4 and 0.4 for Zn, Pb, Cd, Cu, Hg and As, respectively.

Recently, **Agardy and Nemerow, (2010)** showed that high levels of Asbestos in industrial sites, it's ranged between 0.0- 2.7 f/cc inside and 0.007 - 3.0 f/cc outside. Malignant pleural mesothelioma (MPM) is becoming an increasing problem in Egypt. MPM is related to inhalation of asbestos fibers in low counts and is incurable when diagnosed. Close to asbestos production companies. Mesthelioma incidences increased from 159 cases during 1984 – 1999 to 733 cases during 2000- 2005.

Mohamed *et al.*, (2011) assessed the environmental impact of some industrial in Helwan. The activity concentration of 226Ra, 232Th, 40K and 137Cs in soil, plant and some waste samples at the industrial facilities in Helwan City in Egypt were measured using γ-ray spectrometry to estimate the radiation hazard as well as establishing a database for radioactivity levels in Helwan City. The concentrations of these radionuclides were compared with the typical world values. Radium equivalent (Raeq), representative level index (Iγr), dose rate and annual effective dose were estimated.

Study Area

Four positions have been chosen surrounded Helwan area for sampling (Table 1) as Helwan, Kafr El- Aloy, Tebbin and Masaara. Sampling time had involved the period from Sept 2014 to June 2015 on intervals every three months.

Measurements were taken both within the Helwan Industrial Area as the main air pollution source in Cairo. Helwan city is located in the southern part of Cairo. It covers an area of 35 km2, bounded to the north by Kafr EI-Alwy, to the east by El-Autostorade way and to the west by the River Nile. The population in the region is 524,686. They habit an area of 19.9 km2. Helwan City has 524,686 populations and considered as one of the greater industrial area in Greater Cairo region. It contains 16.5% of the total industrial activities in Cairo. It contains 21 facilities which represent 16.5 % of the total industrial activities in Cairo. It has different industrial activities (Cement, Metallurgy, Metals, Spinning & Weaving, and many others) which contribute directly to the pollution of the city. Measurement sites were selected on the basis of the dispersion characteristics of the pollutants in the atmosphere, and to ensure a variety of distances from the Helwan, Kafr El- Alwy, Tebbin and Masaara. Three types of source of information were used.

Table.1: Sites of measurements

Site No.	Latitude	Longitude
01 (In Front Of Iron & Steel Factory)	29°47'12.54"N	31°19'59.59"E
02 (Arab Saeid behind the iron and steel)	29°45'10.58"N	31°18'25.44"E
03 (In front of manufacturers of red brick and fertilizer)	29°45'17.25"N	31°19'22.43"E
04 (In front of cement factories)	29°55'13.90"N	31°17'42.24"E
05 (El Dabaa Axial road, Sheikh Zayed City)	30°4'15.18"N	30°54'36.50"E

Fig. 1: Measurement Sites

Climate

Meteorological data

The proposed sites were influenced by a Mediterranean climate and the rainy season is winter (from December to Febrauray). There are some sharp storms that arise and be coming from the Libyan deserts. Fig.2 explains the various weather data during the study area in 2014, which included the major averages temperatures and Minor during the months of the year and the movement of wind as well as rainfall.

The temperature (max, min and mean), degree days (heating, cooling and growing), dew point, precipitation and wind speed as well as sea level pressure of autumn season of the year 2014 are presented in table (2) and figure (2). It was found that, the max and min temperature were significantly increased in March. This was reflected on the mean temperature as it is realized 34, 23 and 13 degrees throughout the year with the max temperature at summer season and the minimum at winter correspondingly. Likewise, the dew point fluctuated through the year. On the opposite manner, the barometric pressure values of the three months decreased significantly through the season. Finally, the wind speed reached its maximum on January with nearly 16 km/h (Table 2 and Fig. 2).

Table.2: Meteorological parameters in 2014

Parameter		Max	Ave	Min
Temperature	Max Temperature (°C)	43	28	15
	Mean Temperature (°C)	34	23	13
	Min Temperature (°C)	30	18	2
Degree Days	Heating Degree Days [base 65]	10	1	0
	Cooling Degree Days [base 65]	30	9	0
	Growing Degree Days [base 50]	44	23	5
Dew Point (°C)		18	12	-11
Precipitation (mm)		7.9	0.0	0.0
Wind (km/ h)		36	10	0
Sea Level Pressure (hPa)		1028	1014	1002

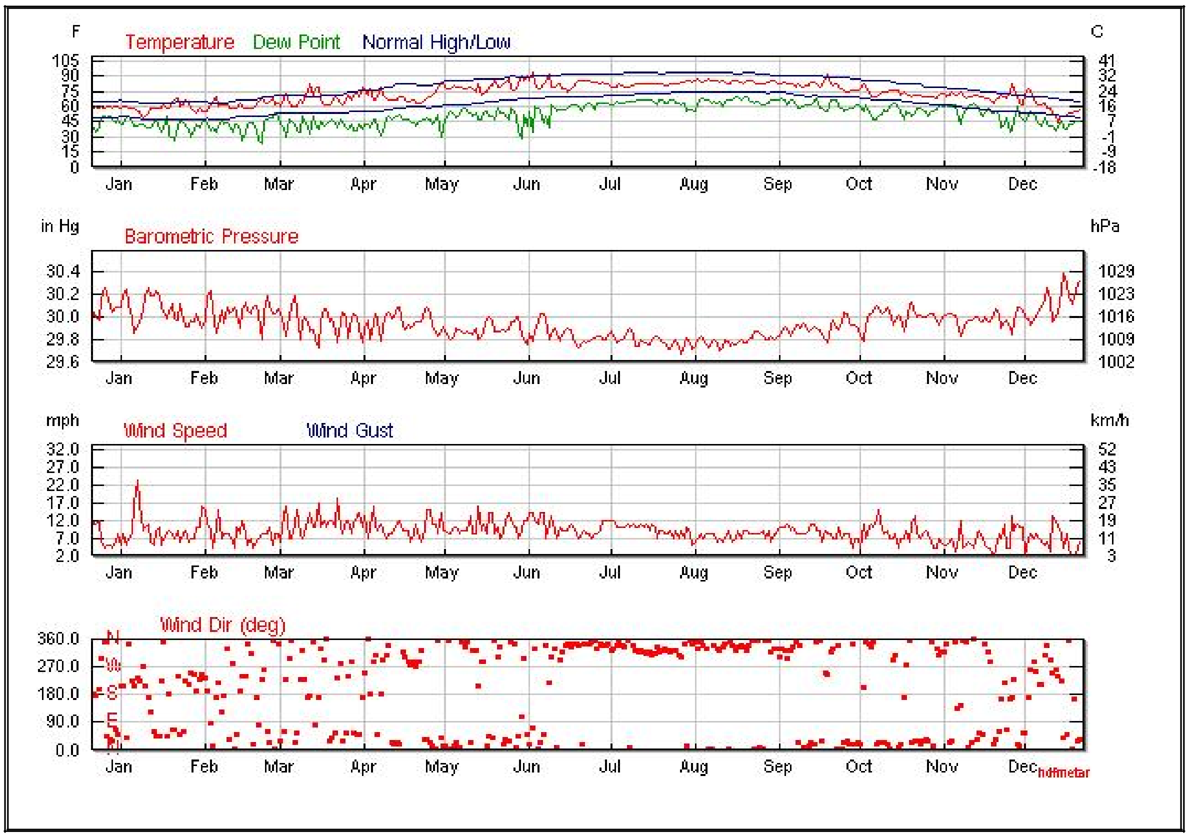

Fig. 2: Temperatures, rates of rainfall and wind speed in all months of 2014.

Wind speed and direction

The wind speed as well as its direction are presented in figure (3). It was found that, the speed and direction varied significantly in the winter season according to other seasons of the year with maximum speed from 15 to more than 20 km/h with direction north east and south west mainly. In the other seasons the speed ranged from low speed (2-5 km/h) to above average (15-20 km/h) and concentrated between the north east and north directions (Fig. 3).

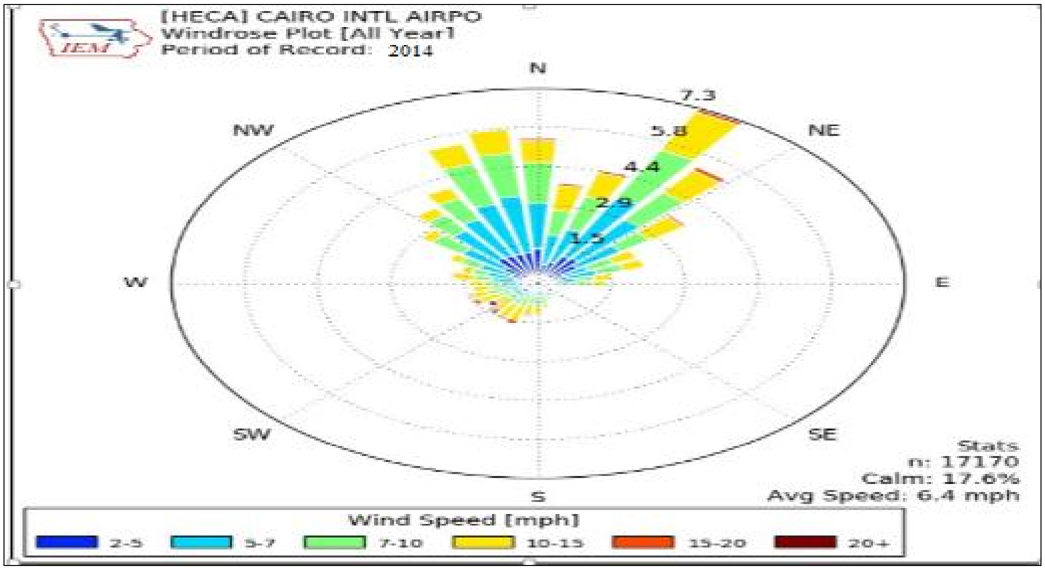

Fig.3: Annually data for wind speed and wind direction

Materials and Methods

Plant materials

Calotropis procera (Family: Asclepiadaceae) is a common native desert milkweed shrub found throughout the tropical arid world from Morocco to India and South East Asia **(Orwa et al., 2009).** In the arid regions it is most often found in disturbed and over- grazed areas (Millerand, 1988). It has also been introduced accidentally or as an ornamental shrub to similar habitats as far West as Hawaii and South into Australia. *Calotropis procera* is an important species in the Northern deserts of the United Arab Emirates and its presence is essential for the support of a unique community of animals **(Khan, 1989)** and provides a critical nursery habitat for other valuable plants **(Castaldi *et al.*, 2004).**

Measurements

Measurements of the pollutant concentration levels in four residential are as chosen for the study during the period of Sept 2014 to June 2015 on intervals every three months in Helwan, Kafr El-Alwy, Tebbin and Masaara.

Measurements of the aerosol and metals originate from various main sources (Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), carbon monoxide (CO), particulate Matter (PM_{10}) and surface ozone (O_3)). From Helwan, Kafr El-Alwy, Tebbin and Masaara for the same period of Sept. 2014 to June 2015.
Determination of cement dust and smoke particles.

Determination of heavy metals either in air, collected plants and soil. Finally, the effects of pollution interaction will carry out on plans and soil.

Assessment of heavy metals contamination

The following parameters are used for determining the contamination of soil:

1-Enrichment factor (EF)

The enrichment factor of metals is a useful indicator reflecting the status and degree of environmental contamination **(Feng, *et al*, 2004).** The EF was calculated using the method proposed by **Sinex and Helz, (1981),** as follows:

EF= (Me/Fe) sample / (Me/Fe) background

Where: Me/Fe sample, is the metal to Fe ratio in the sample of interest, Me/Fe background, is the natural background value of metal to Fe ratio.

2-Contamination Factor (CF)

The level of contamination of sediment by metal is expressed in terms of a contamination factor (CF) calculated as:

CF= Cm sample / Cm background

Where Cm sample, is the concentration of a given metal in soil sample Cm background, is value of the metal equals to the world soil average.

3-Pollution Load Index (PLI) Pollution Load Index (PLI), for a particular site, has been evaluated by following the method proposed by **Tomilinson *et al.*, (1980)**. This parameter is expressed as:

$$PLI = (CF1 \cdot CF2 \cdot CF3 \cdot .... \cdot CFn)^{1/n}$$

Where, n is the number of metals studied and CF is the contamination factor calculated as early described.

4-Geoaccumulation index (I_{geo} Enrichment of metal concentration above baseline concentrations was calculated using the method proposed by **Muller (1969):**

$$I\ geo = Log2\ (Cm\ sample / 1.5Cm\ control)$$

Measurement of air pollutants :

Sampling and measurements were based on the environmental protection agency (EPA) and the American Standard test methods (ASTM). These methods are listed in the next table:

Parameter	Standard Method
Evaluation of Carbon monoxide in air	ASTM D6216
Evaluation of Sulfur dioxide in air	
Evaluation of Nitrogen dioxide in air	
Evaluation of Respiratory Particulate (PM10) in air	NOISH 0600

Instrument Used For Sampling & Measurement

Parameter	Equipment
Evaluation of Carbon monoxide in air	Miran Gas Analyze
Evaluation of Sulfur dioxide in air	
Evaluation of Nitrogen dioxide in air	
Evaluation of Respiratory Particulate (SPM10) in air	Thermo Dust meter

Air pollution index (API):

The average of the sum of the ratios of three major pollutant concentrations to their respective air quality standards were obtained. The average was then multiplied by 100 to get the index **(Rao *et al.*, 1989).** API = 1/3 [(SPM) / (S_{SPM}) + (SO_2) / (S_{SO2}) + (NO_X) / (S_{NOx})] X 100 where S_{SPM}, S_{SO2} and S_{NOx} represent the ambient air quality standards for suspended particulate matter (SPM), SO_2 and NO_x**.**

Determination of elements

Wet ashing method was used for plant material extraction. Plant materials were dried in an oven at 80ºC until a constant weight was obtained. The dried matter was digested according to the method of **Chapman and Pratt (1961)** with some modifications (changing the acids of digestion by adding to them perchloric acid). One gram of ground plant material (oven-dried at 80ºC) was weighed into 250 mL digestion flask which has been previously washed with acid and distilled water. Ten mL mixture of concentrated nitric acid: sulfuric acid: perchloric acid (70%) at the ratio 5: 1: 2 (v/v) were added. The plant extract samples were digested on an electric heater until dense white fumes appeared and finally the solution became clear and was about 5mL. The samples were then left to cool and diluted with distilled water and quantitavely transferred into 50 ml volumetric flask and made up to volume with distilled water. Filtrations were carried out using Whatman No.42 filter paper. Atomic Absorption Spectrophotometer was used (Varian SpectrAA-300) for the determination of cadmium, iron, manganese, phosphorous, chromium, cobalt, cupper, nickle and zinc **(Anonymous, 1989).**

Bioaccumulation factor BAF

$$BAF=C_{shoot}/C_{soil}$$

C_{shoot} and C_{soil} are metals concentration in the plant shoot (mg/kg) and soil (mg/kg), respectively. **(Satpathy *et al.*, 2014)**.

Instruments of the study

PM_{10} and $PM_{2.5}$ monitoring instrument

Casella cell has introduced the Dust Detective Static Air Sampling (SAS) enclosure for exactly this application. This accessory provides a simple solution too short to medium term fixed area monitoring with the Micro-dust pro and Apex sampling pumps and is designed specifically for use in indoor applications, but some short term outdoor perimeter samples can be undertaken with the unit.

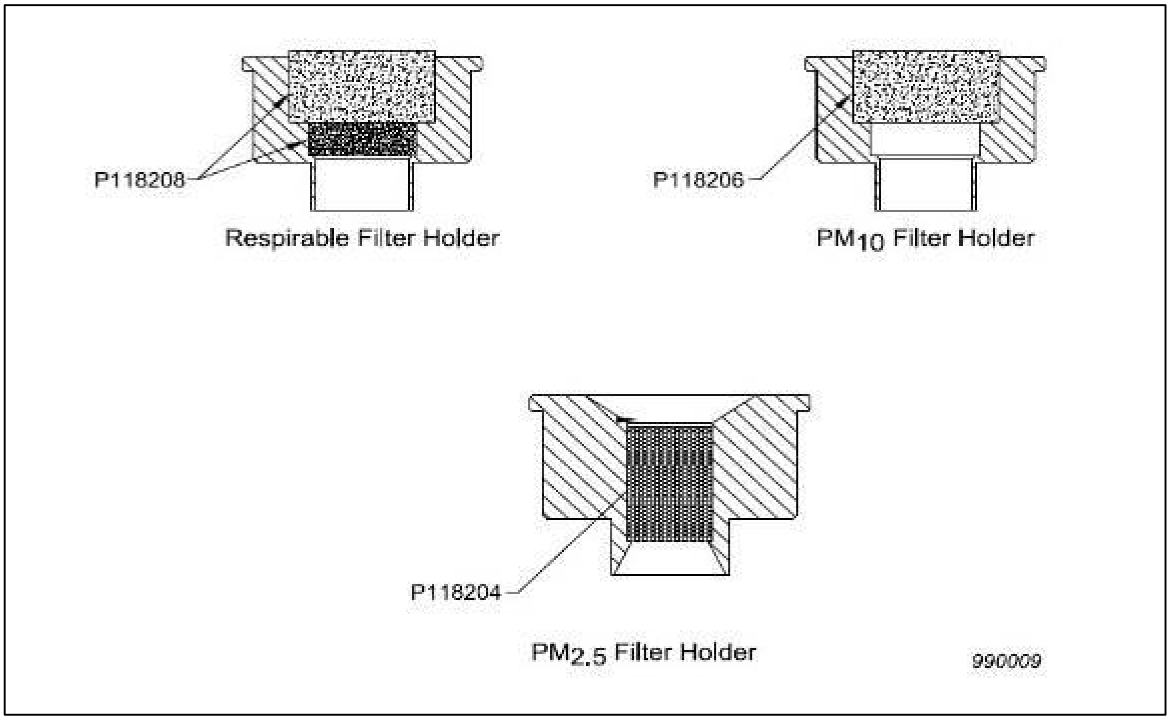

Fig. 4: PUF Filter configurations

After passing through the Micro-dust pro, particulate matter is deposited on a 25 or 37 mm filter which may be used for gravimetric or chemical analysis.

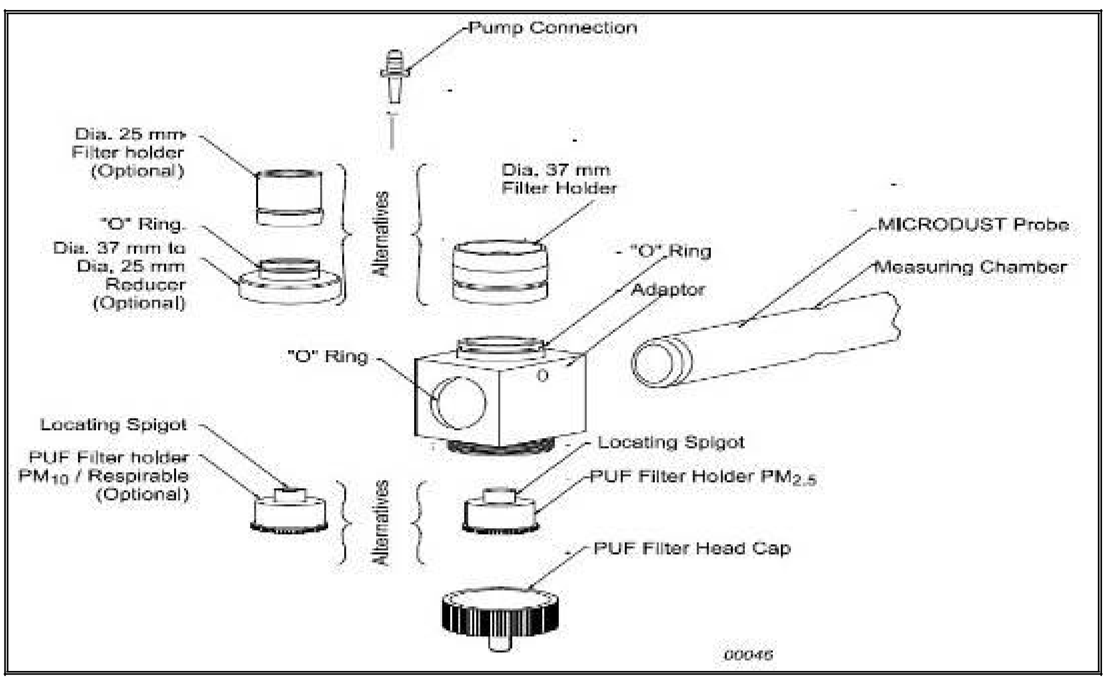

Fig. 5: Adaptor and filter configurations

Data Sources

Egyptian Environmental Affairs Agency (EEAA)

Official web site of EEAA was used in many statements concerning the Egyptian Environmental Law No.4 of 1994 which amended by Law No.9 of 2009, the regulations according to the latest amendments; Prime Minister' decision No. 1095 of 2011 and No. 964 of 2015 amending some provisions of the regulations, as well as annual reports of pollutants monitoring, EEAA have also been guided by Pollution Index (PI) that has been applied for PM_{10} in Cairo.

Central Agency for Public Mobilization and Statistics (CAPMAS)

Annual reports of CAPMAS are used to access to several statistics related to the research subject.

Data analysis

Data were analyzed by the one-way analysis of variance (ANOVA). Differences between dose groups were further tested by the Duncan's test. Statistical calculations were performed using a SPSS program software (Statistical Package for the Social Sciences), and differences were considered as significant when P < 0.05

Results and discussion

Biochemical analysis of Specimen: soil, plant leaves and stems in winter and summer seasons

Heavy metals in soil in winter

The rates of concentrations of cadmium, lead, copper, zinc and iron for soil collected from the different sites in winter season were recorded in table (3).

Lead has higher rate of concentration at all of the four sites followed by cadmium with significant rates.
The highest rate of concentration of lead was in the site 2 (Helwan Fertilizers Company) with 9.40 µg/ gm dry wt., while it reached its lowest at the site 4 (Tourah Portland Cement Co.).

All metals were belonging to very high contamination category all the sites near the factory except iron.

Table (3): Heavy metals rates of concentrations in soil in winter season 2014

Soil/Winter	Cadmium (µ/ gm)	Lead (µg/ gm)	Copper (µg/ gm)	Zinc (µg/ gm)	Iron (µg/ gm)
Site 1	$1.19^a \pm 0.11$	$6.65^c \pm 0.28$	$0.06^c \pm 0.01$	$0.29^{ab} \pm 0.05$	$0.59^b \pm 0.05$
Site 2	$1.37^a \pm 0.14$	$9.40^a \pm 0.75$	$0.09^a \pm 0.0$	$0.33^a \pm 0.03$	$0.68^a \pm 0.05$
Site 3	$0.60^c \pm 0.09$	$7.66^b \pm 0.58$	$0.08^b \pm 0.01$	$0.20^c \pm 0.02$	$0.46^c \pm 0.03$
Site 4	$0.76^{bc} \pm 0.13$	$2.81^d \pm 0.31$	$0.04^d \pm 0.01$	$0.19^c \pm 0.01$	$0.36^d \pm 0.03$
Site 5 (control)	$0.94^b \pm 0.08$	$2.28^d \pm 0.20$	$0.04^d \pm 0.01$	$0.23^{bc} \pm 0.05$	$0.46^c \pm 0.04$
F	23.211*	130.320*	36.738*	8.596*	26.831*
p	<0.001*	<0.001*	<0.001*	0.003*	<0.001*

Data was expressed by using mean ± SD.
F,p: F and p values for **ANOVA test**, Sig. bet. grps was done using **Post Hoc Test (LSD)**
Means with **Common letters** are not significant (Means with **Different letters** are significant)
*: Statistically significant at $p \leq 0.05$

Heavy metals in shoot in winter

The change in the heavy metals for the plant species (*Calotropis procera*) were recorded in Table (6). The rates of concentrations of cadmium, lead, copper, zinc and iron for stem collected from the different sites in winter season were recorded in table (4).

The highest heavy metals values were lead (10.14± 0.60 µ /g dry Wt.) in site 3 (Clay Bricks Companies) then cadmium in the same site ($3.39^a \pm 0.21$ µ/g dry Wt.) and iron ($2.97^a \pm 0.14$µ /g dry Wt.).

The lowest values for all heavy metals (Tourah Portland Cement Co.)

Table (4): Heavy metals rates of concentrations in shoot in winter season 2014

Shoot/Winter	Cadmium (µ/ gm)	Lead (µg/ gm)	Copper (µg/ gm)	Zinc (µg/ gm)	Iron (µg/ gm)
Site 1	$1.64^{c} \pm 0.14$	$6.54^{c} \pm 0.32$	$0.07^{a} \pm 0.0$	$1.41^{a} \pm 0.10$	$2.57^{b} \pm 0.21$
Site 2	$2.19^{b} \pm 0.17$	$8.31^{b} \pm 0.30$	$0.08^{a} \pm 0.0$	$1.22^{bc} \pm 0.13$	$2.31^{bc} \pm 0.16$
Site 3	$3.39^{a} \pm 0.21$	$10.14^{a} \pm 0.60$	$0.11^{a} \pm 0.01$	$1.41^{a} \pm 0.10$	$2.97^{a} \pm 0.14$
Site 4	$1.67^{c} \pm 0.14$	$4.63^{e} \pm 0.34$	$0.19^{a} \pm 0.26$	$1.08^{c} \pm 0.07$	$2.13^{c} \pm 0.15$
Site 5 (control)	$1.76^{c} \pm 0.16$	$5.83^{d} \pm 0.28$	$0.07^{a} \pm 0.0$	$1.29^{ab} \pm 0.10$	$2.89^{a} \pm 0.15$
F	59.016^{*}	95.053^{*}	0.606	5.794^{*}	14.765^{*}
p	$<0.001^{*}$	$<0.001^{*}$	0.667	0.011^{*}	$<0.001^{*}$

Data was expressed by using mean ± SD.
F,p: F and p values for **ANOVA test**, Sig. bet. grps was done using **Post Hoc Test (LSD)**
Means with **Common letters** are not significant (Means with **Different letters** are significant)
*: Statistically significant at $p \leq 0.05$

Heavy metals in plant leaves in winter

The change in the heavy metals for the plant species (*Calotropis procera*) were recorded in Table (5). The rates of concentrations of cadmium, lead, copper, zinc and iron for plant leaves collected from the different sites in winter season were recorded in table (5).

The highest heavy metals values were lead (10.14± 0.60 µ /g dry Wt.) in site 3 (Clay Bricks Companies) then cadmium in the same site ($3.39^{a} \pm 0.21$ µ/g dry Wt.) and iron ($2.97^{a} \pm 0.14$µ /g dry Wt.).

The lowest values for all heavy metals were recorded in site 4 (Tourah Portland Cement Co.)

Table (5): Heavy metals rates of concentrations in plant leaves in winter season 2014

Leaves/Winter	Cadmium (µ/ gm)	Lead (µg/ gm)	Copper (µg/ gm)	Zinc (µg/ gm)	Iron (µg/ gm)
Site 1	$1.77^{a} \pm 0.10$	$4.51^{b} \pm 0.18$	$0.05^{b} \pm 0.0$	$1.04^{b} \pm 0.07$	$2.09^{b} \pm 0.19$
Site 2	$1.81^{a} \pm 0.14$	$6.04^{a} \pm 0.22$	$0.06^{a} \pm 0.0$	$0.79^{c} \pm 0.06$	$1.52^{c} \pm 0.13$
Site 3	$1.01^{b} \pm 0.09$	$6.03^{a} \pm 0.20$	$0.07^{a} \pm 0.0$	$0.64^{c} \pm 0.07$	$1.25^{c} \pm 0.17$
Site 4	$0.86^{b} \pm 0.11$	$6.03^{a} \pm 0.20$	$0.04^{c} \pm 0.0$	$1.23^{a} \pm 0.14$	$2.66^{a} \pm 0.15$
Site 5 (control)	$1.84^{a} \pm 0.15$	$4.90^{b} \pm 0.35$	$0.05^{d} \pm 0.01$	$1.18^{ab} \pm 0.09$	$2.70^{a} \pm 0.26$
F	46.517^{*}	29.636^{*}	22.025^{*}	24.765^{*}	38.302^{*}
p	$<0.001^{*}$	$<0.001^{*}$	$<0.001^{*}$	$<0.001^{*}$	$<0.001^{*}$

Data was expressed by using mean ± SD.
F,p: F and p values for **ANOVA test**, Sig. bet. grps was done using **Post Hoc Test (LSD)**
Means with **Common letters** are not significant (Means with **Different letters** are significant)
*: Statistically significant at $p \leq 0.05$

Heavy metals in soil in summer

The change in the heavy metals for the plant species (*Calotropis procera*) were recorded in Table (6). The rates of concentrations of cadmium, lead, copper, zinc and iron for soil collected from the different sites in summer season were recorded in table (6).

The highest heavy metals values were zinc (17.82 ± 0.59 µ /g dry Wt.) in site 4 (Tourah Portland Cement Co) then lead in site 3 (Clay Bricks Companies) (10.20 ± 0.95µ/g dry Wt.)

Table (6): Heavy metals rates of concentrations in soil in winter season 2014

Soil/Summer	Cadmium (µ/ gm)	Lead (µg/ gm)	Copper (µg/ gm)	Zinc (µg/ gm)	Iron (µg/ gm)
Site 1	$2.67^{c} \pm 0.21$	$7.50^{b} \pm 0.30$	$0.80^{bc} \pm 0.10$	$13.88^{b} \pm 1.09$	$3.34^{a} \pm 0.30$
Site 2	$2.97^{bc} \pm 0.15$	$9.47^{a} \pm 0.25$	$1.36^{a} \pm 0.16$	$14.97^{b} \pm 1.46$	$2.91^{b} \pm 0.20$
Site 3	$3.47^{a} \pm 0.32$	$10.20^{a} \pm 0.95$	$0.90^{b} \pm 0.10$	$10.84^{c} \pm 1.04$	$1.19^{c} \pm 0.09$
Site 4	$3.27^{ab} \pm 0.32$	$4.80^{c} \pm 0.27$	$0.54^{d} \pm 0.04$	$17.82^{a} \pm 0.59$	$3.51^{a} \pm 0.25$
Site 5 (control)	$3.47^{a} \pm 0.26$	$4.52^{c} \pm 0.18$	$0.67^{cd} \pm 0.12$	$17.57^{a} \pm 1.48$	$1.38^{c} \pm 0.13$
F	5.331^{*}	87.097^{*}	23.540^{*}	17.895^{*}	82.210^{*}
p	0.015^{*}	$<0.001^{*}$	$<0.001^{*}$	$<0.001^{*}$	$<0.001^{*}$

Data was expressed by using mean ± SD.
F,p: F and p values for **ANOVA test**, Sig. bet. grps was done using **Post Hoc Test (LSD)**
Means with **Common letters** are not significant (Means with **Different letters** are significant)
*: Statistically significant at $p \le 0.05$

Heavy metals in shoot in summer

The change in the heavy metals for the plant species (*Calotropis procera*) were recorded in Table (7). The rates of concentrations of cadmium, lead, copper, zinc and iron for shoot collected from the different sites in summer season were recorded in table (7).

The highest heavy metals values were zinc (24.30 ± 2.05µ /g dry Wt.) in site 1 (Egyptian Iron and Steel Co.) then in site 2 (Helwan Fertilizers Company) cadmium in the same site (18.53 ± 0.42µ/g dry Wt.) and iron (2.97^{a} ± 0.14µ /g dry Wt.).

The lowest values for all heavy metals was copper in site 4 (Tourah Portland Cement Co.)

Table (7): Heavy metals rates of concentrations in shoot in summer season 2014

Shoot/Summer	Cadmium (µ/ gm)	Lead (µg/ gm)	Copper (µg/ gm)	Zinc (µg/ gm)	Iron (µg/ gm)
Site 1	$4.60^{bc} \pm 0.26$	$13.63^{c} \pm 0.99$	$7.53^{a} \pm 0.92$	$24.30^{a} \pm 2.05$	$13.53^{b} \pm 1.19$
Site 2	$5.27^{b} \pm 0.21$	$15.63^{b} \pm 0.40$	$4.06^{a} \pm 0.15$	$18.53^{b} \pm 0.42$	$10.37^{c} \pm 1.46$
Site 3	$8.93^{a} \pm 0.95$	$17.37^{a} \pm 0.99$	$4.60^{a} \pm 0.53$	$8.53^{d} \pm 0.81$	$15.87^{a} \pm 1.12$
Site 4	$4.36^{c} \pm 0.12$	$9.50^{d} \pm 0.21$	$3.65^{a} \pm 0.45$	$12.63^{c} \pm 1.25$	$12.30^{bc} \pm 1.14$
Site 5 (control)	$4.44^{bc} \pm 0.26$	$10.67^{d} \pm 0.72$	$24.58^{a} \pm 40.29$	$17.80^{b} \pm 1.93$	$17.17^{a} \pm 0.72$
F	51.943^{*}	60.866^{*}	0.732	52.582^{*}	16.818^{*}
p	$<0.001^{*}$	$<0.001^{*}$	0.590	$<0.001^{*}$	$<0.001^{*}$

Data was expressed by using mean ± SD.
F,p: F and p values for **ANOVA test**, Sig. bet. grps was done using **Post Hoc Test (LSD)**
Means with **Common letters** are not significant (Means with **Different letters** are significant)
*: Statistically significant at $p \le 0.05$

Assessment of heavy metals contamination.

The Enrichment factor, Contamination factor, Pollution load index and Geoaccumulation factor for the soil collected from the different sites (1- Egyptian Iron and Steel Co., 2- Helwan Fertilizers Company ,3- Clay Bricks Companies and 4 -Tourah Portland Cement Co.) were recorded in tables (8-11).

Lead and Copper have the higher enrichment factor at Site 3 followed by 2 with significant enrichment.

Site 3 has the highest heavy metals enrichment factor followed by site 2.

All metals were belong to very high contamination category at the site 3.

The contamination factor reached its maximum at site 2 of lead in winter season (4.124) then site 3 while its minimum was in site 3 of Zinc in summer season.

Table (8): Enrichment factor (EF) of metals in the soil collected from different sites (1, 2, 3, and 4) during summer and winter 2014.

Cadmium		Winter	Summer
Soil	Site 1	1.00	0.32
	Site 2	0.99	0.40
	Site 3	0.64	1.16
	Site 4	1.05	0.37
Lead		**Winter**	**Summer**
Soil	Site 1	2.29	0.68
	Site 2	2.79	0.99
	Site 3	3.34	2.61
	Site 4	1.59	0.42
Copper		**Winter**	**Summer**
Soil	Site 1	1.07	0.49
	Site 2	1.54	0.96
	Site 3	1.84	1.57
	Site 4	1.25	0.32
Zinc		**Winter**	**Summer**
Soil	Site 1	0.97	0.33
	Site 2	0.95	0.40
	Site 3	0.87	0.71
	Site 4	1.05	0.40

Table (9): Contamination factor (CF) of metals in the soil collected from different sites (1, 2, 3, and 4) during summer and winter 2014.

Cadmium		Winter	Summer
Soil	Site 1	1.274	0.768
	Site 2	1.459	0.855
	Site 3	0.641	0.999
	Site 4	0.811	0.941
Lead		**Winter**	**Summer**
Soil	Site 1	2.917	1.659
	Site 2	4.124	2.094
	Site 3	3.360	2.257
	Site 4	1.234	1.063
Copper		**Winter**	**Summer**
Soil	Site 1	1.361	1.200
	Site 2	2.279	2.035
	Site 3	1.852	1.355
	Site 4	0.967	0.810
Zinc		**Winter**	**Summer**
Soil	Site 1	1.243	0.790
	Site 2	1.400	0.852
	Site 3	0.871	0.617
	Site 4	0.814	1.014
Iron		**Winter**	**Summer**
Soil	Site 1	1.275	2.426
	Site 2	1.478	2.111
	Site 3	1.007	0.864
	Site 4	0.775	2.547

Table (10): Pollution load index (PLI) of metals in the soil collected from different sites (1, 2, 3, and 4) during summer and winter 2014.

Soil/Winter	Cadmium (µ/ gm)	Lead (µg/ gm)	Copper (µg/ gm)	Zinc (µg/ gm)	Iron (µg/ gm)
Site 1	0.227	0.599	0.301	0.22	0.233
Site 2	0.285	0.74	0.477	0.28	0.29
Site 3	0	0.65	0.42	0.064	0.124
Site 4	0.0323	0.21	0.12	0.04	0.018
Soil/Summer	**Cadmium (µ/ gm)**	**Lead (µg/ gm)**	**Copper (µg/ gm)**	**Zinc (µg/ gm)**	**Iron (µg/ gm)**
Site 1	0.011	0.345	0.2	0.22	0.508
Site 2	0.057	0.446	0.43	0.055	0.44
Site 3	0.12	0.47	0.25	0	0.0606
Site 4	0.09	0.15	0.03	0.13	0.53

Table (11): Geoaccumulation index (Igeo) of metals in the soil collected from different sites (1, 2, 3, and 4) during summer and winter 2014.

Heavy metal / Season	Winter	Summer
Cadmium	0.991	0.887
Lead	2.657	1.699
Copper	1.535	1.280
Zinc	1.054	0.805
Iron	1.102	1.833

Bioaccumulation factor

Bioaccumulation factor (BAF) values for the plant species ***(Calotropis procera)*** were recorded in table (12).

The bioaccumulation factor for *Calotropis procera* (table 12) was shown to be less than 1 in site 1 and 2 in lead while, the highest BAF shown to be Iron in site 3 (13.333) in summer season followed by site 3 (6.918) Zinc in winter season and then Iron but in winter season at site 3 also (6.410).

Table (12): Bioaccumulation factor (BAF) for *Calotropis procera* at different sites (1, 2, 3, 4) during summer and winter 2014.

		Winter	Summer
Cadmium	Site 1	1.372	1.725
	Site 2	1.600	1.775
	Site 3	5.656	2.577
	Site 4	2.202	1.336
Lead	Site 1	0.983	1.818
	Site 2	0.883	1.651
	Site 3	1.324	1.703
	Site 4	1.645	1.978
Copper	Site 1	1.253	9.413
	Site 2	0.849	2.993
	Site 3	1.416	5.092
	Site 4	4.856	6.753
Zinc	Site 1	4.874	1.751
	Site 2	3.745	1.238
	Site 3	6.918	0.787
	Site 4	5.684	0.709
Iron	Site 1	4.381	4.052
	Site 2	3.392	3.567
	Site 3	6.410	13.333
	Site 4	5.981	3.508

Air pollution parameters April 2014

Air pollution parameters (carbon monoxide (mg/m^3), sulfur dioxide (mg/m^3), nitrogen dioxide (mg/m^3) and Volatile organic compounds (VOCs) (mg/m^3) were recorded in table (13).

The values of the pollutants were higher in the site 3 followed by site 1 and the lowest values were at site 3 and 4. The most abundant gas pollutant was nitrogen dioxide followed by carbon monoxide.

The nitrogen dioxide ranger from 118.3 to 149.8 mg/m3 and carbon monoxide ranged from 3.6 to 12.9 mg/m3

Table.13: Shows Results of gases Measurements (April 2014)

Site No.	Gases	Concentration			AQL
		Max.	Min	Average	
01	CO	7.6	1.50	4.55	30 mg/m^3
	NO_2	123.6	18.70	71.15	300 µg/m^3
	H_2S	0.4	0.1	0.25	350 µg/m^3
	VOCs	0.244	0.005	0.125	NO. AQL
02	CO	3.7	1.3	2.50	30 mg/m^3
	NO_2	118.5	16.3	67.40	300 µg/m^3
	H_2S	0.2	0.1	0.15	350 µg/m^3
	VOCs	0.06	0.02	0.040	NO. AQL
03	CO	12.9	3.2	8.05	30 mg/m^3
	NO_2	149.8	12.1	80.95	300 µg/m^3
	H_2S	0.3	0	0.15	350 µg/m^3
	VOCs	0.65	0.11	0.380	NO. AQL
04	CO	3.6	1.1	2.35	30 mg/m^3
	NO_2	118.3	4.2	61.25	300 µg/m^3
	H_2S	0.4	0.1	0.25	350 µg/m^3
	VOCs	0.237	0.176	0.207	NO. AQL
Control	CO	0.32	0.12	0.22	30 mg/m3
	NO_2	15	1.9	8.45	300 µg/m3
	H_2S	0.003	0.001	0.002	350 µg/m3
	VOCs	0.042	0.017	0.259	NO. AQL

Total Suspended Particulate (TSP), and Particulate matter less than 10 µm (PM_{10}), $PM_{2.5}$ and $PM_{1.0}$ (June 2014)

The changes in the air quality limits in ambient and working environment were recorded in Table (16). The changes of total suspended particles recorded after 24 hours, 12 months and for 8 hours of exposure season were recorded in Table (16).

The highest value of TSP was in site 3 (In front of manufacturers of red brick and fertilizer) with (494.5 µg/m^3), PM10 296.7 µg/m^3 and PM2.5 178.0µg/m^3

The lowest values were in site 4 (In front of cement factories).

Air pollution parameters June 2014

Air pollution parameters (carbon monoxide (mg/m^3), sulfur dioxide (mg/m^3), nitrogen dioxide (mg/m^3) and Volatile organic compounds (VOCs) (mg/m^3) were recorded in table (14).

The values of the pollutants were higher in the site 3 followed by site 1 and the lowest values were at site 3 and 4. The most abundant gas pollutant was nitrogen dioxide followed by carbon monoxide.

The nitrogen dioxide ranged from 93.09 to 70.438 mg/m^3 and carbon monoxide ranged from 9.26 to 2.703 mg/m$^{3.}$ all organic and in organic recorded concentration lower than AQL.

Table.14: Shows Results of organic and in organic gases, June 2014

Site No.	Gases	Concentration			AQL	Conc./AQL %
		Max.	Min	Average		
01	CO	8.74	1.725	5.23	30 mg/m^3	17.43
	NO_2	142.14	21.505	81.82	300 µg/m^3	27.27
	H_2S	0.46	0.115	0.29	350 µg/m^3	0.08
	VOCs	0.281	0.0058	0.144	NO. AQL	
02	CO	4.255	1.495	2.88	30 mg/m^3	9.60
	NO_2	136.275	18.745	77.51	300 µg/m^3	25.84
	H_2S	0.23	0.115	0.173	350 µg/m^3	0.05
	VOCs	0.069	0.023	0.046	NO. AQL	
03	CO	14.835	3.68	9.26	30 mg/m^3	30.87
	NO_2	172.27	13.915	93.09	300 µg/m^3	31.03
	H_2S	0.345	0	0.173	350 µg/m^3	0.05
	VOCs	0.7475	0.127	0.437	NO. AQL	
04	CO	4.14	1.265	2.703	30 mg/m^3	9.01
	NO_2	136.045	4.83	70.438	300 µg/m^3	23.48
	H_2S	0.46	0.115	0.288	350 µg/m^3	0.08
	VOCs	0.27255	0.202	0.238	NO. AQL	
05	CO	0.23	0.265	0.513	30 mg/m^3	0.11
	NO_2	13	2.83	8.069	300 µg/m^3	5.78
	H_2S	0.003	0.001	0.021	350 µg/m^3	0.06
	VOCs	0.034	0.020	0.022	NO. AQL	

TSP, PM10 and PM2.5 Measurements April, 2014

The concentration of TSP was higher than AQL of EEAA, in site, 1, 2 and 3. The concentration of PM10 and PM2.5 were higher than AQL in sites 1 and 3 as shown in table 15. Sites 4 and 5 recorded concentrations lower than AQL for TSP, PM10, and PM2.5 as shown in table (15) .

Table.15: Measurements of TSP, PM_{10} and $PM_{2.5}$

Site No.	Parameters	Conc. (µg/m^3)	AQL For EEAA (µg/m^3)	% of concentration to AQL
01 (In Front of Iron& Steel Factory)	TSP	287	230	124.8
	PM_{10}	172.2	150	114.8
	$PM_{2.5}$	103.3	100	103.3
02 (Arab Saeid behind the iron and steel)	TSP	233	230	101.30
	PM_{10}	139.8	150	93.20
	$PM_{2.5}$	83.9	100	83.90
03 (In front of manufacturers of red brick and fertilizer)	TSP	430	230	186.9
	PM_{10}	258	150	172.0
	$PM_{2.5}$	154.8	100	154.8
04 (In front of cement factories)	TSP	197	230	85.7
	PM_{10}	118.2	150	78.8
	$PM_{2.5}$	70.9	100	70.9
Control (Sheikh Zayed City)	TSP	45	230	24.6
	PM_{10}	28	150	4.9
	$PM_{2.5}$	19	100	19.0

Table 16: Air Quality Limits (µg/m^3) of TSP in ambient and working Environment 2014

Site No.	Parameters	Conc. (µg/m^3)	AQL For EEAA (µg/m^3)	% of concentration to AQL
01 (In Front Of Iron & Steel Factory)	TSP	330.1	230	143.5
	PM_{10}	198.0	150	132.0
	$PM_{2.5}$	118.8	100	118.8
02 (Arab Saeid behind the iron and steel)	TSP	267.9	230	116.5
	PM_{10}	160.8	150	107.2
	$PM_{2.5}$	96.5	100	96.5
03 (In front of manufacturers of red brick and fertilizer)	TSP	494.5	230	215.0
	PM_{10}	296.7	150	197.8
	$PM_{2.5}$	178.0	100	178.0
04 (In front of cement factories)	TSP	226.6	230	98.5
	PM_{10}	135.9	150	90.6
	$PM_{2.5}$	81.5	100	81.5
05 (Control)	TSP	45	49	38.8
	PM_{10}	28	32	25.5
	$PM_{2.5}$	19	25	14

The morphological investigations

The macro morphological investigations revealed that *Calotropis procera* occurs as a single or many stemmed soft-wooded shrub, and occasionally a tree reaching to 6m. Leaves are opposite-decussate, simple, ovate to obovate with 4-6 pairs of sub-opposite nerves prominent on the abaxial surface, an acute apex, sessile (almost decurrent) base, a pale green colour, and quite large which is about 30 x 25 cm 10. Flowers; Regular, bisexual, liliac or pale rose, purple or light greenish yellow and have a faint color. They are arranged in simple or rarely compound cymose corymbs at the ends of laterally placed or interpetiolar peduncles arising from alternate sides of the nodes. Each cluster is surrounded by an involucre of several small oblong pointed scaly caducous bracts, flower buds ovoid. Calyx; five lobes broadly ovate with small fleshy teeth like glands within the base, Corolla; regular, gamopetalous, pale rose purple or liliac, subcordate to broadly sub-campanulate with a short tube and five broad ovate, lanceolate, valvate, spreading lobes, and roecium; five stamens, inserted at the base of the corolla. Filaments united to form a large stamina column provided with five conspicuous radiating coronal appendages that are completely adnate to, but slightly shorter than the column. The appendages are fleshy, pale purplish or yellowish white and laterally compressed with a circinnately recurved hollow corsal spur at base and two short obtuse obliquely divergent cuticles towards the top just below the apex. Anthers short, broad, somewhat horny with broadly triangular membranous anther tips that are inflexed over the sides of the stigmatic hood. Gynoecium; In florescence arise from the base of the leaves in pedunculate (c.7cm) cymes of 3-20. Fruits consist of green, spongy ovoid fruits (follicles), up to 15 cm long by 10 cm wide. They split open to release plumed, papery light brown seeds with a pappus of white filaments up to 6 cm long on one side. (Figure 6)

The study revealed that the primary vein category is pinnate with 3 basal veins. The secondary vein category festooned brochidodromous with decreasing secondary vein spacing and angles toward base.

The inter secondaries are weak. Tertiary veins arise at acute angle to primary vein with inconsistent angle variability, ramified course and random reticulate category. Quaternary vein category is dichotomizing. Areolation is moderately developed. The freely ending ultimate veins one branched while the marginal ultimate venation looped. The stomato graphic investigation revealed that the abaxial epidermal cells appeared to be irregular shape in surface view with sinuous anticlinal walls. Trichomes are wanting. Stomata are elliptical in shape and paralytic type. The stomatal index is 26.180%. Adaxial epidermal cells are on the same ground plan as in the abaxial epidermis except in; stomata wanting. Concerning stem and lamina anatomy stem is terete. Epidermal cells are tangentially or radically elongated with thick cuticle. Trichomes are glandular, eglandular and unicellular. Cortex with 2-3 layers of colleenchyma followed by 7-10 layers of polyhedral parenchyma followed by 9 rows of sclernchyma in the form of patch fibers. Vascular tissue shows a continuous cylinder with circular ring porous vessels. Pith is solid of thin walled parenchyma with idioplasts. The leaf is differentiated into midrib and two wings, the epidermal cells are tangentially or radially elongated with thick cuticle. Trichomes are glandular, eglandular and unicellular. Mesophyll tissue in midrib region is differentiated ab- and adaxially into 2-3 rows of annular collenchymas and8-9 rows of polyhedral parenchyma. The vascular tissue in crescent shape. Wings contain 3 rows of palisade tissue adaxially and 5 rows of spongy tissue abaxially, so the leaf type is dorsiventral.

General observations on the investigated area showed that plants environment has been adversely affected by factory emissions. Changes in plant height, canopy area, leaf area, total plant biomass, chlorophyll and necrosis may indicate the adverse effects of toxic gases such as fluoride, SO_2 and allocation of dry matter at the polluted sites.

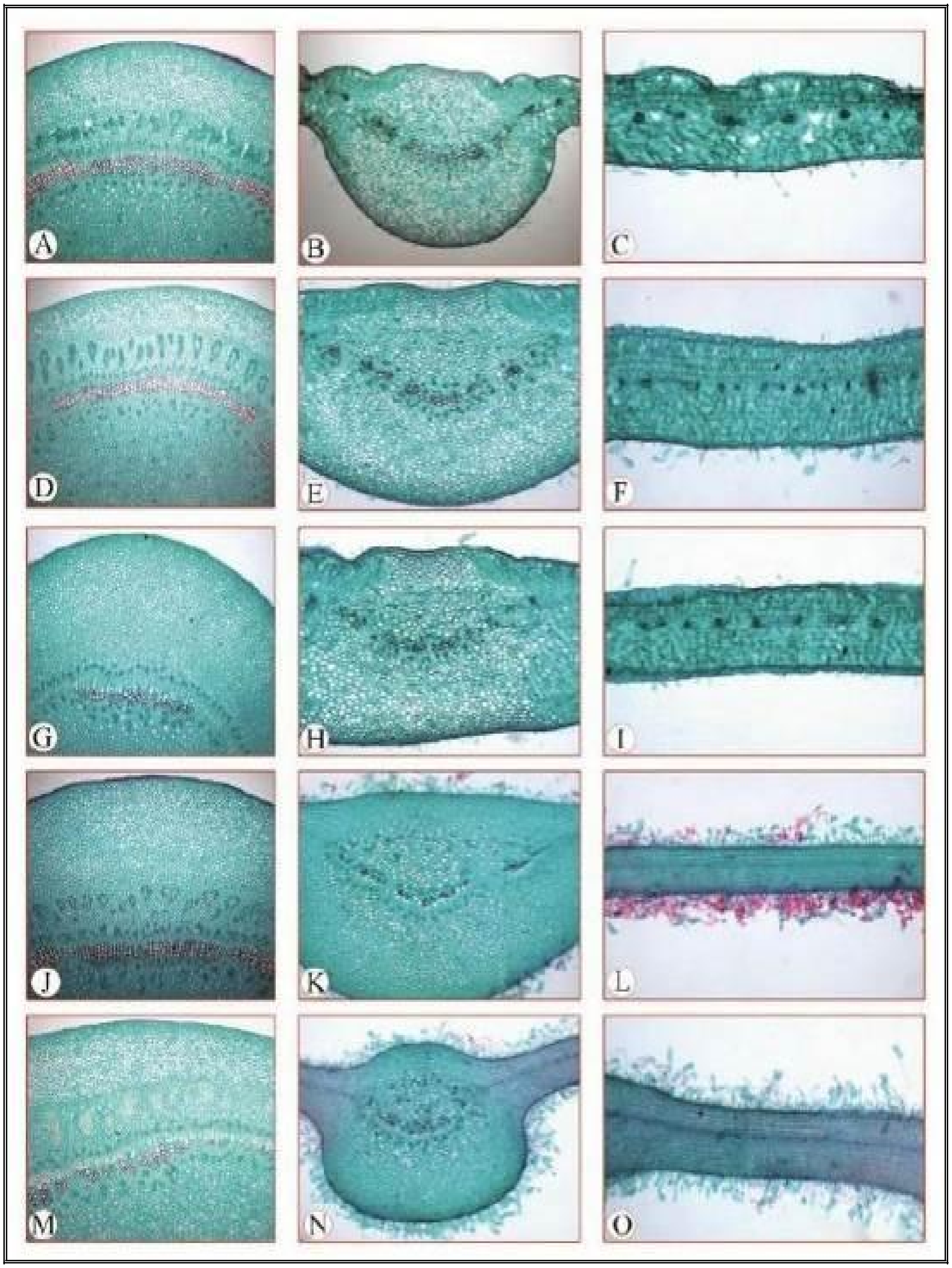

Fig.6: Photomicrographs of stem, midrib and wing of *Calartopis procera* collected from different localities; A-C. control. D-F. locality
1. G-I. locality 2. J-L. locality 3. M-O. locality 4. X=2.

Soil pollution

Because of the presence of the fertilizer factory **(Helwan fertilizer company)** soil and air pollution in that area has been documented in sites near the factory.

The values of heavy metals were shown to be high at the factory site and decreased with increase the distance from the factory as contamination can be diffused or localized **(van DER Perk, 2006; Horta *et al.*, 2015).**

The most important problems from diffuse sources are acidification **(State of the Environment Committee, 2011)** which had been recorded in our study.

Solubility and speciation of metals in the soil solution mainly controlled by pH of soil. Thus, each unit decrease in PH results in approximately two-fold increase in the concentration of the metals **(Muwanga, 1997).**

Air pollution

Air pollution has become an extremely serious problem for the modern industrialized world **(Rai *et. al.*, 2011)** and become a serious environmental problem to trees and crops **(Chauhan and Joshi 2008).**

Agricultural development mainly depends on phosphate fertilizers production. During the manufacturing processes of phosphate fertilizer plants, several air emission (NH_3), and particulates (SPM) **(Salama, 2013).**

Pollution due to fertilizer industry was found in varying degrees in air, water and soil. According to (**Thakkar, 2013)** all fertilizer factories cause gaseous emissions which recorded in our study by the increase in air pollutants at the factory if compared with other sites.

Air pollution index for different sites showed that the factory had high effect on the air quality as the sites under the influence of the factory have severe air pollution or heavy air pollution if compared with the control which has light air pollution.

Both soil and air pollution found to have great effect on the vegetation and physiology of plants at the study area which discussed below.

Effect of soil and air pollution on plant analysis

To study the effect of the dust from the cement, brick, steel and fertilizer factories on biochemistry of plants we choose one plant species: *Calotropis procera*, the response of this species to the pollution was quite remarkable.

Heavy metals content:

Heavy metals accumulate at soil top and with time their contamination increases in the soil, leads to the absorption and accumulation in plants increases. similar results were reported by F**ilipovic- Trajkovic *et al.* (2012) and Tzvetkova and Petkova (2015).**

Metal accumulation and bioavailability effected by soil properties, climate conditions, plant genotype, the type of plant root system and the response of plants to elements **(Kabata-Pendias 2001)**

Bio-accumilation factor is used in the determination of the degree of intake and component storage of toxic compounds in plants and animals **(Connell, 1997).**

The threat of environmental pollution elements has attracted attention as much as the air pollution. Concentrations of many trace elements in the environment have been significantly affected by man's activities. Environmental pollution was increased by increasing the industry development all over the world and especially in Egypt; increment of these pollution caused many hazards for all organisms

Findings from the present study showing that: The concentrations of TSP, PM10, (114.8) and PM2.5during months of the study period are TSP (124.8), PM10 (114.8) and PM2.5 (103.3) which are Similar to a study by **(Rashed *et al.*, 2010).**

Conclusion

General observations on the investigated area showed that plants environment hasn't been affected by factory emissions. No changes in plant height, canopy area, leaf area, total plant biomass, chlorophyll and necrosis which can't be used as an indication of the adverse effects of toxic gases such as fluoride, SO_2 and allocation of dry matter at the polluted sites.

The results showed that the internal parts of the leaf and shoot in the *Calotropis procera* plant are not affected by concentrations of air pollutants found in

Helwan industrial area air or even high concentrations of soil which reflects its high capacity to adapt and grow in the region. This leads us to the fact that the plant cannot do the biological treatment because it cannot get rid of contaminants such as the heavy metals recorded in the study, the concentrations in the parts of the plant after the laboratory examination are lower than compared to pollutants in the air and soil, despite the apparent ability to grow and adapt in this The industrial environment saturated with pollution due to the presence of many different sources.

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