Phytoremediation of The Air Pollution Using some Plants in Three Different Locations of Alexandria City

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ABSTRACT: The present study was carried-out at the Horticulture Research Institute, Agriculture Research Center (A.R.C.). Alexandria, Egypt during the spring and autumn seasons of 2015. The aim was to investigate the effect of phytoremediation of air pollution using some plants (*Nerium oleander and Pittsporum Tobira*) in three locations in the Alexandria city**.** We applied these work in three different sites in Alexandria city which namely, (1) El-Ebrahimeya, (2) El- Dekhela and (3) Antoniadis garden (Control). The results showed that the concentrations of lead, cadmium and zinc elements were the highest in the Dekhela region soil compared with other areas . Lead element was a higher concentration at the sector 30-60cm compared with the sector 0-30cm. Analyzing the leachates of polluted leaves, stem and roots, it has been detected that in both species studied, the concentrations of lead, cadmium ans zinc was the highest in Dekhela compared with those obtained in Antoniades garden region.

Key word: Phytoremediation – Pollution – Lead - Cadmium – Zinc - *Nerium oleander* - *Pittsporum tobira* - Alexandria city.

INTRODUCTION

Alexandria is the second capital of Egypt, it was the old capital, located on the Mediterranean coast. Alexandria city, one of the most culturally diverse and civilized cities, where many different historical periods throughout the ages have seen, where there are many ancient and modern monuments, became an open museum featuring Greek, Roman, Coptic and Islamic. The population of Alexandria city is about 4,123,869 people according to 2006 census (World Population Prospects) serving commercial, industrial and agricultural activities. Therefore, the issue of pollution is one of the important issues that threatened the throne of the tourist city, especially air pollution standpoint (Ghattas,1992). In Alexandria, some industrial areas started to contribute to the problem of air pollution due to the rapid growth of industrialization, besides the lack of planning for site allocation of industries. Therefore, there were a considerable numbers of studies on industrial air pollution and its effects on the environment in Alexandria. For instance, for the cement industry, many researchers tackled the problem of pollution monitoring, control, health effects and other factors caused by this industry (Abd El-Kader *et al.*,1979). Amer (1999) studied air pollution and planning of housing location in Alexandria.

Lead is widely distributed naturally, but the greatest risks normally arise from emissions to the environment associated with human use of the metal and its derivatives. Fumes and dust come from smelting of lead, manufacture of insecticides, paint, powdery glazes and storage batteries, and from gasoline containing lead additives. Sewage sludge may contain very high levels of lead and its use as a fertilizer may contaminate soils. High levels may occur in urban air as a result of the high traffic density and associated emission of lead from gasoline additives (Harrison and Laxen, 1981). Madany and Salim (1992), found that the concentration of lead in street and house dust were 697.2, and 360 µg/m^3; respectively. It was suggested that the motor vehicles are the major source of these metals in dust samples.Jaffe *et al.*(1992) measured lead concentration in urban and rural area. Urban concentrations were higher than rural concentration, Ghattas (1992). He found that the lead concentration in air of Alexandria, Cairo was averaged 0.259 µg/m^3.

Cadmium is a normal constituent of soil and water at low concentrations. It is usually mined and extracted from zinc ores, especially zinc sulphide. Industrially, cadmium is used as an antifriction agent, and in alloys. In the environment, cadmium is dangerous because many plants and some animals absorb it efficiently and accumulate it within their tissues. Shalaby (1997) found that cadmium concentraion in air samples in urban area and rural area was 0.028, and 0.002µg/m^3; respectively. Ghattas (1992) measured cadmium concentration in ambient environment at Alexandria, near Horreya avenue and found that Cd concentration was 0.0053 µg/m^3.

Major uses of zinc are in the production of noncorrosive alloys, brass and in galvanizing steel and iron products. Zinc undergoes oxidation as surface coating, thus protecting the underlying metal from degradation. Zinc oxides are used in rubber and as a white pigment. Zinc is utilized therapeutically in human medicine in the treatment of zinc deficiency. The carbonates, which are organic zinc compounds, are used as pesticides (Friberg *et al.*, 2002).Also they found that about 21-38 x 10^3 metric tons of zinc per year is fallout. Shalaby (1997) found that zinc concentration in air samples in urban and rural area was of 0.5, 0.44, and 0.11µg/m^3; respectively.

This study aims to see experimentally the effect of using two kinds of plants; *Nerium oleander and Pittsporum tobira* on reducing the air pollution level in three locations in Alexanderia city; El-Ebrahimeya, El-Dekhela and Antoniadis garden. Three highly dangerous heavy metals were detected through the study; Lead, Cadmium and Zinc.

MATERIAL AND METHODS

The present study was carried-out at the Horticulture Research Institute, Agriculture Research Center (A.R.C.) Alexandria, Egypt during the spring season (March-April) and the autumn season (October-November), 2015. The aim was to investigate the effect of phytoremediation of air pollution using one year old unpinched plants of (*Nerium oleander and Pittsporum tobira*) of about 50 cm height. 24 plants of each shrub were planted in three locations in Alexandria city **.**We applied these work in three different sites in Alexandria city namely:

1- El-Ebrahimeya square which considered as a densely populated region and logged of a lot vechicles.
2- El- Dekhela region which is considered as an industrial region.
3- Antoniadis garden (Smouha) which is considered as a control region(less polluted).

1. Sampling:

1.1. Sampling of Total Suspended Particulate (TSP), Particulate Matter Less Than 10 micrometer (PM_{10}) , Lead, Cadmium and Zinc:

Samples were collected inside the working environment during the melting process and carried out using portable dust sampler type L-2SF.MK3 from Rotheroe and Michell. The sampler has a regulated air flow rate of 50 - 110 liter per minute. The inlet manifold of volume sampler was two meters height from the ground surface. Samples were collected on Whatman GF/A fiberglass filter of 7 cm diameter with a 99% - >99.99% collection efficiency for 0.035 - 1 µm particles (Kathren, 1984).

1.2. Digestion Method:

For measuring lead, cadmium and zinc concentrations, the filter paper was placed in desiccators for 48 hrs prior and after the sampling. The analytical balance (Meter) of 0.1 mg sensitivity was used. Digestion method was carried out following the method of Thompson and Walsh (1983) and WMO (1993) for airborne samples.

2. Monitoring instruments

2.1. TSP, PM_{10} and $PM_{2.5}$(Particulate matter Less Than 2.5 micrometer)

With increased awareness of environmental pollution from fine particulate in the workplace and increasing enforcement of Control of Substances Hazardous to Health (COSHH) and environmental legislation, the demand for more area and perimeter monitoring on a short to medium term basis is on the increase. This need for real-time particulate information is a requirement in general industry, when looking at Total Suspended Particulate (TSP), and at inhalable and respirable dust levels as a health issue.

CASELLA CEL has introduced the Dust Detective Static Air Sampling (SAS) enclosure for exactly this application. This accessory provides a simple solution to 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 (Ashraf, 2013).

The key component to this accessory is the sampling inlet which utilizes Polyurethane foam (PUF) size-selective filter techniques. The foam filter specifications and dimensions determine the desired aerosol size selection characteristics and eliminate particle sizes greater than PM_{10}, $PM_{2.5}$ or Respirable (4 mm) as appropriate. The larger particles become trapped and collect within the foam matrix, whilst all particles below these “cut-off points” pass through the PUF filters and enter the measurement chamber, where the real time mass concentration is established (Ashraf, 2013).

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

2.1.1.Starting a Sample Run

The following procedure was applied:

1. The protective dust cap was removed and the sample was fit inlet tube/head to the case.
2. The PUF filter foam (s) was inserted and in line sample filter.
3. The Micro dust pro was switched and Apex pump on.was confirmed zero using the in-line filter connected to the sample inlet.
4. The Apex flow was checked that rate was set to 3.5L/min.
5. The unit was located in required location.Pump and Microdust data logger was started according to their respective user manuals.

2.1.2 GPS

Global Positioning System (GPS) device was used to determine the measurement locations on Alexandria map.

2.1.3 Digital Camera

Digital camera has been used to document measurements and monitoring the nature of the surrounding environment.

2.2 Data Sources

2.2.1 Metrological Data

Several websites were used to get recent weather data in measurement sites such as Weather Underground (http://www.wunderground.com/)and the Iowa Environmental Mesonet (IEM) (http://mesonet.agron.iastate.edu/).

2.2.2 Calculation Methode for TSP (Total Suspended Particulate) and PM_{10} (Particulate Matter Less Than 10 Micrometer).

The level of Total suspended particulate(TSP) and the level of respiratory particles(PM_{10}) at the three selected locations was calculated as showen :{(Average of TSP before- Average of TSP after new filter)/ AQL}*100, and the same equation for PM_{10} :{(Average of PM_{10} before- Average of PM_{10} after new filter)/ AQL}*100,the AQL(Air Quality Limit) for air pollutant according to law 4/94 which modified to law 9 for 2009 (Egyptian Environment Affairs Agency,1994).

2.3. Sample preparation:

We washed the collected samples (leaves, stems and roots of the two shrubs) with distilled water to clean dust and deposited substance we recorded the fresh weight for every collected sample, after that all samples were dried on papers then oven dried at 70Cº for 48 hours to constant mass, after putting them in paper bags. After washing the samples we kept the leachates water obtained from the washed samples in jars to determine heavy metals as it's content described by Haswel (1991).

The samples of water of all plant part leachates of both shrubs (*Nerium oleander* and *Pittsporum tobira*) were washed with it which were put in jars (18 jars) and were given a code for doing chemical analysis as determination of heavy metals especially (Cd, Zn and Pb) by using the Atomic Absorpation Spectrometer.

2.4. Soil analysis:

Soil samples of shrubs understudy were taken at random from surface 0-30 cm and at depth 30-60 cm, dried in the oven for determination of heavy metals (Cd, Zn and Pb), these samples were digested as follows:

- A sample of soil was dried very well and was siftted with sieve it's scale 2mm.
- A weight was taken from the soil about 0.5g.
- 4ml of Nitric acid was put for the sample (HNO_3).
- 1ml of Prochloric was put for the sample ($HCLO_4$).
- The solution was headted at 105º for 2-3 hour until appear white fumes then the temperature was raised to 185º until the solution became dry.
- The residue was left to be cool then 2 ml of hydrcloric acid (HCL) was added then was heated on 60ºfor one hour.
- The mixture was cooled and 8ml of distill water was added then was left for 4 hour after that was nominated and was continued to 50 ml of distill water to be ready to take the reading from the apparatuse.
- After that the digested sample of soil was taken for doing chemical analysis as determination of heavy metals especially (Cd- Zn and Pb) determination using Atomic Absorpation Spectrometer according to Isaac and Kerber (1971).

Correlation relationships were statisticaly analysed by Gomez and Gomez (1984), in order to detect the relationships among the three pollutants (Pb, Zn and Cd) each of TSP (Total Suspended Particulate) and PM_{10} (Particulate Matter Less Than 10 micrometer).

RESULTS AND DISCUSSION

1. Heavy metals (lead, cadmium and zinc) content in soil

Data presented in Table (1) showed that, in season 2015, for the *Nerium* and *Pittsporum* plants,it was found that the concentration of lead element was the highest in the Dekhela region soil compared with other areas, while lead element was manifested in higher concentration in the layer of 30-60 cm compared with the layer of 0-30 cm. The lowest amount was accumulated in Antoniadis garden in the same depth. Also, it has been found that the concentration of cadmium element was the highest in the Dekhela region compared with the other areas, while cadmium element was found in higher concentration in the layer of 30-60 cm compared with the layer of 0-30 cm. The lowest concentration was accumulated in Antoniadis garden in the same depths. In addition, the concentration of zinc element was the highest in the Dekhela region compared with other areas, while zinc element was obtained of a higher concentration in the layer of 30-60 cm compared with that of the layer of 0-30 cm. The lowest amount was accumulated in Antoniadis garden in the samples taken from the same depth. Some limited differences among the three pollutants with respect to their concentration in spring and autumn. It is believed that these differences might due to the traffic density.

Table (1). Heavy metals (lead, cadmium and zinc) content in the soil planted with *Nerium and Pittsporum* in the different locations.

Treatments			Lead (mg/kg)		Cadmium (mg/kg)		Zinc (mg/kg)	
			Spring	Autumn	Spring	Autumn	Spring	Autumn
Nerium oleander	**Antoniadis (Control)**	**D1**	2.820	2.745	0.015	0.010	1.220	3.875
		D2	4.815	4.675	0.023	0.026	2.705	6.230
	Dekhela	**D1**	39.600	22.470	0.077	0.185	7.485	9.725
		D2	46.295	34.900	0.152	0.237	9.070	15.885
	Ebrahimeya	**D1**	8.605	8.235	0.023	0.018	4.520	5.380
		D2	9.985	10.945	0.066	0.039	5.530	9.010
Pittsporum tobira	**Antoniadis (Control)**	**D1**	1.645	3.000	0.014	0.019	1.070	3.150
		D2	2.100	5.120	0.025	0.030	2.050	5.580
	Dekhela	**D1**	27.150	19.585	0.165	0.259	5.625	8.880
		D2	31.455	24.830	0.320	0.398	8.185	10.750
	Ebrahimeya	**D1**	4.020	7.945	0.021	0.011	3.935	5.170
		D2	5.940	9.895	0.040	0.025	5.130	6.620

D1: soil sample at depth of 0-30 cm.
D2: soil sample at depth of 30-60 cm.

2. Heavy metals (lead, cadmium and zinc) content in water

Data presented in Table (2) displayed the level of lead in leachates samples resulted from washing leaves, stems and roots of the two shrubs (*Nerium oleander* and *Pittsporum tobira*) in the spring and autumn seasons of 2015. It was found that high concentration of lead in leaves growing at region of Dekhela compared for concentration the low in Antoniadis garden. With respect to the leachates level of lead in stems, high level was found in Dekhela region, relative to that obtained from Antoniadis garden. The leachate of roots for the both shrubs (*Nerium oleander* and *pittsporum tobira*) showed that high concentration of lead was found in Dekhela region vs. the lowest concentration was found in Antoniadis.

With respect to level of cadmium in the leachate leaves, stems and roots of both two shrubs (*Nerium oleander and Pittsporum tobira*) in the spring and autumn season of 2015, the highest concentration of cadmium was detected in leaves of the shrubs growing at Dekhela region, while concentration was found in those growing at Antoniadis garden. The level of lead in leachate of stem showed also the high level of cadmium in Dekhela region, while the lowest level was found in Antoniadis garden. The leachate of roots of both shrubs (*Nerium oleander and Pittsporum tobira*) displayed the highest concentration of cadmium in roots of shrubs growing at Dekhela region as it compared with those indicated at Antoniadis garden.

As for the zinc concentration, it was found that the level of zinc in leachates of leaves, stems and roots of (*Nerium oleander and Pittsporum tobira*) shrubs in the spring and autumn season of 2015,the highest zinc level was obtained in leaves of the shrubs growing at region of Dekhela, compared with that obtained at Antoniadis garden. The level of zinc in the leachates of stems showed also that the highest level of zinc was found in stems of shrubs growing at Dekhela region, while the lowest level was found in those of shrubs growing at Antoniadis garden.The leachates of roots of both shrubs (*Nerium oleander and Pittsporum tobira*) showed that highest concentration of zinc at Dekhela region compared to those at Antoniadis garden. Some limited differences among the three pollutants with respect to their concentration in spring and autumn. It is believed that these differences might due to the traffic density.

Table (2). Heavy metal content in leachates of plant parts (mg/l).

Plant	Location	Leaves						Stem						Root					
		Lead content (mg/l)		Cadmium content (mg/l)		Zinc content (mg/l)		Lead content (mg/l)		Cadmium content (mg/l)		Zinc content (mg/l)		Lead content (mg/l)		Cadmium content (mg/l)		Zinc content (mg/l)	
		Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
N. oleander	Anto. (Control)	0.083	0.101	0.0980	0.001	4.8096	0.4403	1.740	0.141	0.0067	0.0006	5.491	0.334	0.071	0.091	0.0065	0.0003	4.539	0.324
	Dekhela	0.416	0.237	0.2904	0.0046	14.089	0.783	4.495	0.304	0.0139	0.0046	17.130	0.884	0.581	0.162	0.0130	0.0050	8.058	0.703
	Ebrahimeya	0.115	0.155	0.1272	0.0033	13.303	0.6506	3.640	0.155	0.0074	0.0030	7.937	0.429	0.123	0.132	0.0083	0.0033	7.724	0.499
P.tobira	Anto. (Control)	0.038	0.091	0.0367	0.0003	3.963	0.195	1.185	0.059	0.0067	0.0002	2.914	0.042	0.098	0.068	0.0057	0.0003	4.745	0.119
	Dekhela	0.514	0.139	0.1893	0.0006	11.100	0.458	3.517	0.155	0.0143	0.0006	11.968	0.262	0.765	0.183	0.0114	0.0006	11.26	0.368
	Ebrahimeya	0.460	0.110	0.1607	0.0003	8.304	0.334	2.412	0.076	0.0100	0.0003	6.961	0.212	0.383	0.122	0.0083	0.0003	6.518	0.266

3. Heavy metals (lead, cadmium and zinc) content (mg/kg) in the filter paper.

Data presented in Table (3) exhibited the results of analyzed filter paper during the spring and autum season of 2015.The results showed that the level of lead in air was high in Dekhela location, but was low in Antoniadis. The level of cadmium was high in Dekhela,as it compared with that of Antoniadis location. The level of zinc in air in Dekhela location was high, it was low in Antoniadis. Some limited differences among the three pollutants with respect to their concentrations in spring and autumn. It is believed that these differences might due to the traffic density.

Table (3). Heavy metal content in filter paper (mg/kg).

Location	Lead content in filter paper (mg/kg)		Cadmium content in filter paper (mg/kg)		Zinc content in filter paper (mg/kg)	
	Spring	Autumn	Spring	Autumn	Spring	Autumn
filter (Control)	2.53	2.66	0.19	0.22	23.82	24.06
Anto.(control)	3.03	3.00	0.20	0.22	32.52	33.17
Dkhela	10.175	13.00	0.61	0.95	45.91	32.64
El-abrahimyia	6.02	6.75	0.29	0.34	36.96	35.20

4. Correlation relationships of Total Suspended particulate (TSP) and Particulate Matter Less Than 10 Micrometer (PM_{10}).

The results showed that the dust fall per 37 days is more than the dust fall per one days in Dekhela region ,while the lowest amount of dusts were found in Antoniadis region as shown in (Table 4 and 5). Which summarize the data of concentration of TSP and PM_{10} in cubic meter which shows that the concentration of TSP and PM_{10} in Dekhela region is more than the concentration of TSP and PM_{10} in Antoniadis region.

4.1. Correlation relationships in *Nerium oleander* plant during 37 days:

Data presented in Table (4) showed significant correlation between Pb and Cd which mean that the source of these pollutant heavy metal is the same which was traffic agent, while incase of medium correlation between Pb and both TSP and PM_{10}these mean that TSP and PM_{10} is a kind of dusts that contains lead. In the other side, there are high correlation between Cd and Zn.

Table (4). Correlation coefficient between the three pollutants (Pb, Zn and Cd) ,TSP(Total suspended particules) and PM_{10}(Particulate Matter Less Than 10 Micrometer) in *Nerium oleander* plant.

	Pb	Cd	Zn	TSP	PM_{10}
Pb	1.00000**	0.604**	0.584*	0.598**	0.598**
Cd	0.604**	1.00000**	0.953**	-0.209$^{n.s}$	-0.2095$^{n.s}$
Zn	0.584*	0.953**	1.00000**	-0.210$^{n.s}$	-0.210$^{n.s}$
TSP	0.598*	-0.209$^{n.s}$	-0.210$^{n.s}$	1.00000**	1.00000**
PM_{10}	0.598*	-0.2095$^{n.s}$	-0.210$^{n.s}$	1.00000**	1.00000**

** Highly significant at 0.01 probability level. * Significant at 0.05 probability level. n.s:not significant

4.2. Correlation relationships in *Pittsporum tobira* plant during 37 days :

Data presented in Table (4) showed a high correlation between Pb and Cd and medium correlation between Pb and Zn. On the other side there is high correlation between Cd and Zn. This means that the source of heavy metal is the same,i.e., traffic agent.

Table (5). Correlation coefficient between the three pollutants (Pb, Zn and Cd) ,TSP(Total suspended particules) and PM_{10}(Particulate Matter Less Than 10 Micrometer) in *Pittsporum tobira* plant.

	Pb	Cd	Zn	TSP	PM_{10}
Pb	1.00000**	0.8285**	0.640**	0.1176*	0.1172*
Cd	0.8285**	1.00000**	0.822**	-0.197$^{n.s}$	-0.198$^{n.s}$
Zn	0.640**	0.8225**	1.00000**	-0.191$^{n.s}$	-0.191$^{n.s}$
TSP	0.1175*	-0.1978$^{n.s}$	-0.1912$^{n.s}$	1.00000**	1.00000**
PM_{10}	0.1174*	-0.198$^{n.s}$	-0.191$^{n.s}$	1.00000**	1.0000**

** Highly significant at 0.01 probability level. * Significant at 0.05 probability level. n.s:not significant

DISCUSSION

According to the results of this study, it was found that the levels of lead, cadmium and zinc in the three location under study were found to be different from one location to another. Both shrubs succeeded to absorb and accumulate heavy metals, but *Nerium oleander* proved to be better.

It was found that the different phytoremediation technologies available to decontaminate soil polluted by heavy metals. With deep root systems and high biomass yields, phytoremediation by trees have huge economic and ecological value, offers a cost-effective and environmental-friendly alternative technology to conventional remediation methods such as soil digging and pumpand-treat systems.Although phytoremediation methods appear to be effective for a wide range of heavy metals, the biological processes behind tree effectiveness are largely unknown. Some important processes that require further investigation are: (a) interaction between tree root system and microbe, (b) chelation mechanisms for heavy metals and (c) biotechnologies suitable for tree phytoremediation (Greger,1999).

Concentrations of metals measured in soils demonstrate that TSP, PM10, lead, cadmium and Zinc values differed greatly according to the agricultural site, plant species, and metal type. The difference as due to locations might be related to soil nutrient management, soil properties, and accumulation of metals, which depends on variety and age of plants, metal levels, and duration of effect (Vassilev and Yordanov 1997). Transfer of metals from soils to plants is dependend on three factors; the total amount of potentially available elements (quantity factor), the activity as well as the ionic ratios of elements in the soil solution (intensity factor), and the rate of element transfer from solid to liquid phases and to plant roots (reaction kinetics) (Greger, 1999). In conclusion, using shrubs as *Nerium oleander and Pittsporum tobira*, polluted air and soil can be remediated, notably at public streets and nearby the source of pollutant agent such as industries.

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الملخص العربى

استخدام بعض النباتات في معالجة تلوث الهواء في ثلاث مناطق مختلفة في الاسكندرية

أشرف عبد الحميد زهران[١]– إيناس زكريا عبد السلام[٢]– نادر أحمد الشنهورى[٣]– نيرة على أحمد[٤]

قسم تقويم الموارد الطبيعية – معهد الدراسات والبحوث البيئية – جامعة مدينة السادات[١]

قسم بحوث تنمية البيئة المستدامة – معهد الدراسات والبحوث البيئية – جامعة مدينة السادات[٢]

قسم بحوث الحدائق النباتية – معهد بحوث البساتين – مركز البحوث الزراعية[٣]

قسم بحوث نباتات الزينة – معهد بحوث البساتين – مركز البحوث الزراعية[٤]

أجريت هذه الدراسة في معهد بحوث البساتين،مركز البحوث الزراعية (A.R.C). الإسكندرية، مصر خلال فصلي الربيع والخريف عام2015 . وكان الهدف هو دراسة تأثير استخدام شجيرات الدفلة و البتسبورم فى معالجة تلوث الهواء في ثلاثة مواقع في مدينة الإسكندرية هي: (١) الإبراهيمية (٢) الدخيلة (٣) حديقة أنطونيادس (مقارنة).

أظهرت النتائج أن اعلى تركيزات من عناصر الرصاص والكادميوم والزنك كانت في تربة منطقة الدخيلة مقارنة مع باقي المناطق تحت الدراسة و كانت التركيزات العالية للعناصر في قطاع التربة عند عمق ٣٠- ٦٠ cm مقارنة مع تلك عند عمق ٠-٣٠ cm . وقد أظهرت البيانات أن مستوى الرصاص والكادميوم والزنك في ماء غسيل الأوراق و السيقان والجذور فى الشجيرات (موضع الدراسة) كانت عالية فى منطقة الدخيلة بينما كانت أقل فى مستوياتها فى منطقة حديقة أنطونيادس. وأظهرت الدراسة ايضا وجود اختلافات عشوائية في قياسات الربيع والخريف تعود الى الكثافة المرورية.