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Evolution Of Air Pollution Tolerance Index Of Selected Plants Chosen For Green Belt Development In Al-Nasiriya City - Southern Of Iraq

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Abstract

Dust is one of the most important air pollutants that the city of Nasiriyah suffers from. Therefore, air pollution tolerance index (APTI) was evaluated in three stations by measuring biological indicators in three plants: Ziziphusspinachristi, Conocarpuslancifolius and Eucalyptus camaldulensis to determine their ability in tolerating the pollutants, in order to select the tolerant plant for building the green belt surrounding Nasiriya city. The study extended from September 2020 to August 2021, and the results showed that Eucalyptus was the most tolerant between the three plants; APTI value for Eucalyptus was (15.02), and according to APTI value (Singh et al., 1991) Eucalyptus considered moderate tolerant for air pollution in Nasiriya.

Keywords: Air Pollution Tolerance Index ; Green Belt ; Al-Nasiriya City ;Iraq

Introduction

Air pollution and its effects are considered one of the most difficult global challenges that damage the general environment and environmental quality. International organizations have warned of the growing danger of air pollution, as it was estimated (Naddafi et al., 2006) World Health Organization (WHO, 2005) , warned the death of 1.3 million people annually due to air pollution. Outdoor air as a result of environmental pollutants and the number of deaths increased to 7 million people in 2012 all over the world and the risk of infection increased respiratory and other diseases (WHO 2016) .In accompany with the increasing in urban density and the means of transportation, it is expected that the level of air pollution will rise higher than it is now, especially the level of concentrations of nitrogen dioxides NO, N2O and ozone O3 (PM Particulate Matter) 10 µg/m3 Particulate matter with sizes less than 10 microns, which led to an increase in mortality by 0.05% (Katsouyanni et al., 2001).

Most cities are exposed to unhealthy air, as nearly 100 million people are exposed to polluted air, which may cause lung and bronchial cancer, results in an estimated 300,000 deaths annually (Keller, 2007). Air pollution, according to the US Environmental Protection Agency, USEPA, 2009, is defined as a deterioration in air quality as a result of the presence of undesirable substances or any substance with concentrations higher than their natural concentrations in the atmosphere, which may result in adverse effects on humans, animals, vegetation and materials. Air pollution is also the most dangerous types of environmental pollution, due to the difficulty of controlling it on the one hand, and its being a factor in polluting other ecosystems such as soil and water (Hill et al., 2010). Dust is one of the most important environmental components in Iraq, due to its geographical location, which is located from dry and semi-arid areas, as well as global climatic changes, such as rising temperatures, increasing evaporation, and falling rains that the country is going through, led to drought and erosion, and this is one of the causes and sources of dust. Overgrazing and razing orchards are among the most important and most dangerous wild sources of dust (Sissakian et al., 2013). Dust particles are usually in sizes ranging from 1 to 100 microns in diameter. The main pollutants depending on the size and diameter of the dust (Pedersen & Calvert, 1990). It is also considered an air pollutant and one of the most complex and dangerous, due to its physical properties, the shape of the particles, their sizes and chemical contents, heavy elements, compounds and gases (Putaud et al., 2010). Plants are among the most sensitive organisms to air pollution and are one of the most important in biological monitoring this can be known by studying the phenotypic, biomonitoring and physiological characteristics of the plant, as the plants show different responses depending on the type of pollutant and their tolerance, or they act as environmental filters for their ability (tolerance for the plant), and from here the plants were classified into pollutant-tolerant plants that are used as bio-sensitive evidence to monitor pollutants, and others that are not tolerant to pollution, and plants are used as biological monitors because they are more reliable than the devices used for monitoring air pollution in addition to their availability, cheapness, accurance, and environmentally friendly nature (Petrova, 2011) .

The aim of study

1- Measuring the amount of falling dust and its chemical and physical properties in the study areas.

2- Evaluation of the concentrations of suspended dust particles (total suspended particles, TSP), and some heavy metals.

3- Knowing some types of plants that are sensitive and tolerant of air pollution by applying the guide to air pollution tolerance on them.

4- Testing the ability of some plant species to treat air pollution through dust retention and absorption .

Methods

Thi-Qar Governorate is one of the governorates of Iraq and is ranked seventh among the governorates of Iraq in terms of area. Its land area is 12,900 km², or 5,000 square miles. It also contains 900 km² of water bodies, its length is 120 meters, and its width is 110 meters. Astronomically, it is at a longitude 45 degrees east of Greenwich, and at a latitude of 12 degrees north of the equator.

Estimation the amount of deposited dust on plant leaves

Plant leaves were collected from the aforementioned leases, and the full-ripened leaves were selected from them. The amount of dust deposited on the surface of plant leaves was calculated by measuring the weight of the leaves with dust with a sensitive scale for the purpose of determining the initial weight. Then the leaves were washed with distilled water and left to dry. The final weight was measured according to the following equation (Prusty et al., 2005).

$$Dust deposition\ mg/cm2 = \frac{W2(mg) - W1(mg)}{A\ (cm2)}$$

Biochemical traits of plants

Relative water content (RWC%)

The relative water content of the plant was extracted according to the following equation(Sivakumaran and Hall, 1978)

Where : $$RWC\ \% = \frac{FW - DW}{TW - DW} \times 100$$

FW: Soft Weight ,taken immediately after removing dust on the leaves

TW: Fullness weight ,taken after overnight soak in distilled water

DW: Dry weight, which is the weight of the leaves after placing them in the oven at 70 degrees for a whole night.

PH

Weighing (0.5)g of the leaves and placing it in distilled water, and the PH was estimated after calibrating the device with calibration solutions.

Total Chlorophyll Content (TCH)

$$TOTALChlorophyll\ (mg/g) = \frac{20.2\ (A645) + 8.02(A663) \times V}{1000 \times W}$$

Through the above equation, the chlorophyll content of the leaf was estimated as described by Singh et al. 1991, by taking (0.2) grams of ground leaves with the addition of 80% acetone, and the kernels were recorded in the spectrophotometer at wavelengths 645 and 663.

$A645$: Absorbance at a wavelength of 645

$A663$: Absorbance at a wavelength of 663

V : final size

W : final weight

Ascorbic acid content

One gram of each sample was weighed and placed in a 25 ml vial, then ascorbic acid (0.05M) and (0.5. meta-Phosphoric acid) were added to it, left in the dark for a whole night. The volume was completed to 25 ml with distilled water, the samples were measured using a spectrophotometer at a wavelength of 760 nm and the results were compared for the absorbance curve with the standards of ascorbic acid, which was prepared previously for the purpose of calculating the value of the concentration of ascorbic acid for each sample (Iqbal et al., 2010).

Air pollution tolerance index (APTI)

In order to know the values of the plant tolerance index, the following method suggested by the researcher (Singh and Rao 1983,) must be followed.

$$APTI = \frac{AA(TCH + P) + RWC\%}{10}$$

AA : Ascorbic acid

TCH : Total chlorophyll content

P : pH degree

RW : Relative water content

APTI value were classified by the researchers into three types: tolerant, medium endurance and sensitive.

Results

Falling dust

The results showed that the lowest rate of falling dust was in the rural area of 8.7 g/m2 during February of the year 2020, while the highest rate was in the industrial area 98.2 g/m2 during March of the same year, and the annual general average was 46.45g/m2 , and the results of the statistical analysis (2020-2021) showed significant differences between months and between sites and the presence of a medium positive correlation with suspended minutes and weak with speed wind, while a negative relationship was found with the relative humidity and the amount of rain .

The results of the frequency distribution percentage (for the volumes of the falling dust particles showed that the predominant volume of dust2- 50 microns in all locations and during all seasons of the year, and it was not recorded the appearance of the size is 2 micron in all sites during the

winter seasons, also no appearance was recorded in all areas of the size 100-250 during the autumn season.

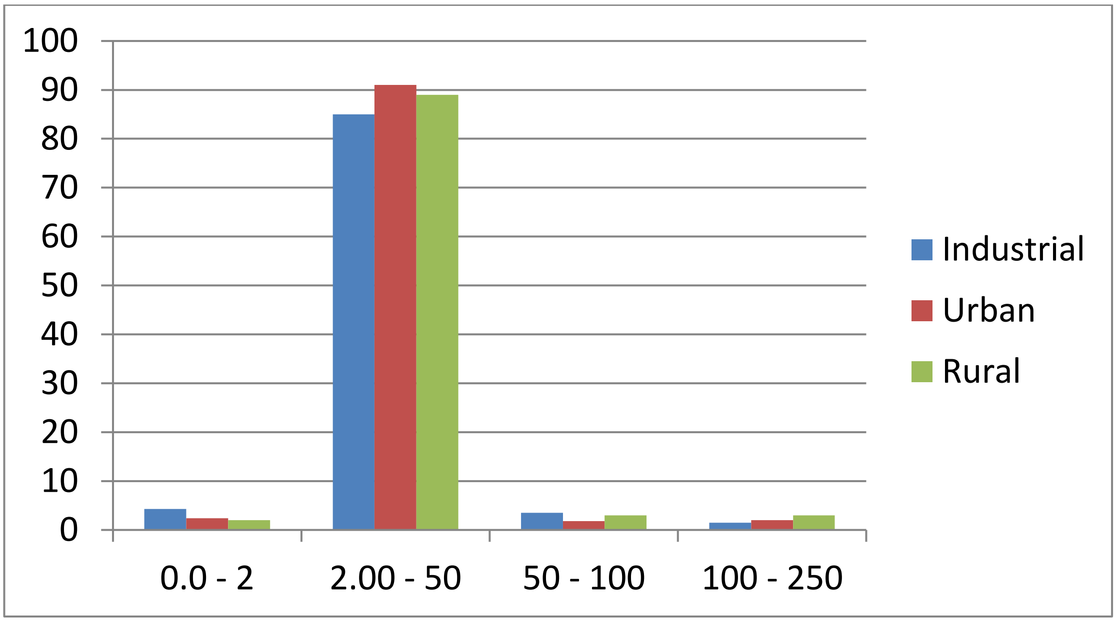

Figure (1) Percentage of dust full size in summer

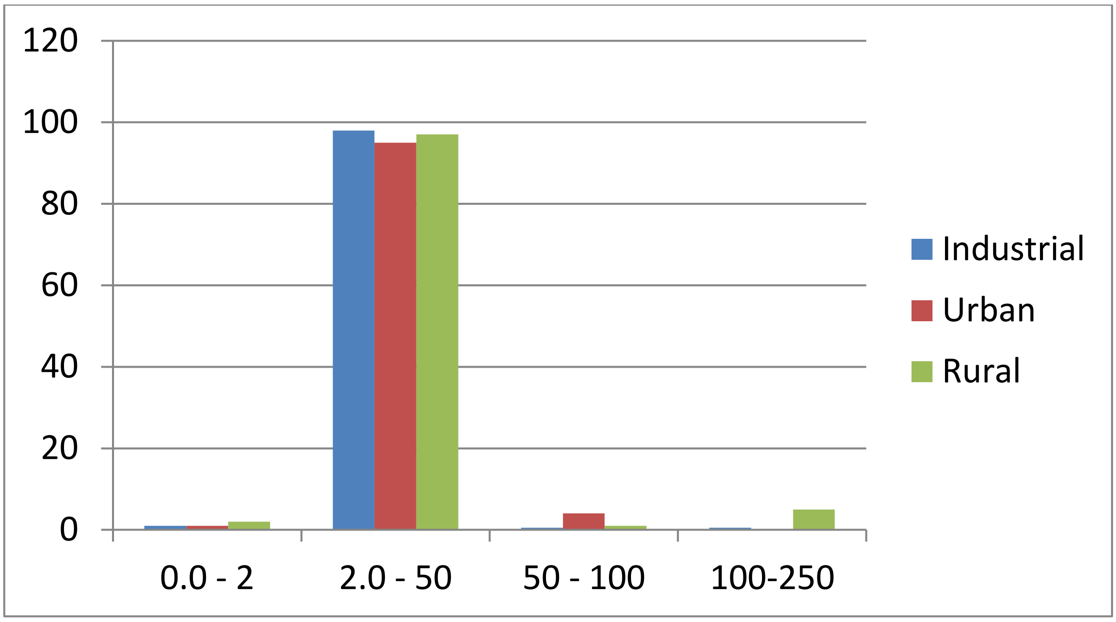

Figure (2) Percentage of dust full size in spring (µm)

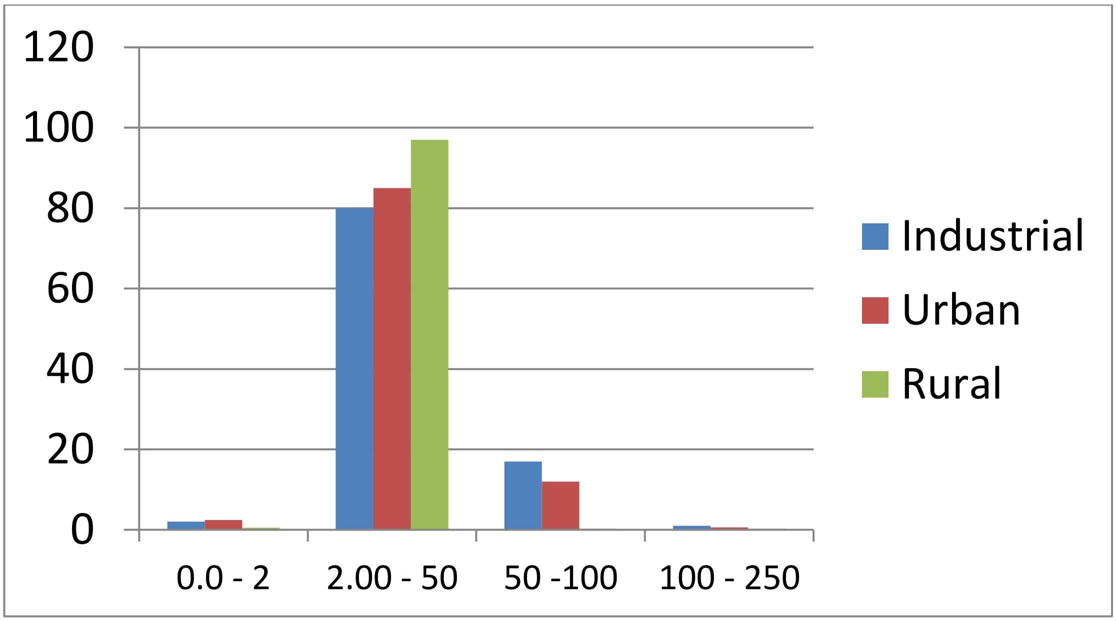

Figure (3) Percentage of dust full size in winter (µm)

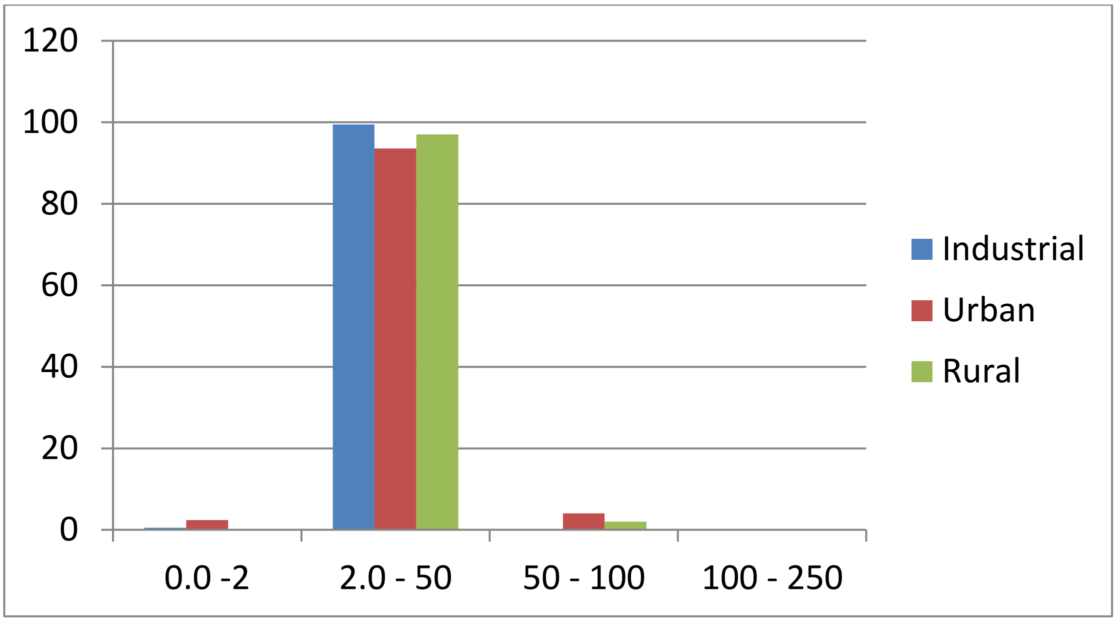

Figure (4) Percentage of dust full size in autumn (µm)

Biochemical analysis of plants

Total chlorophyll content

The results show that the lowest rate of chlorophyll was 1.02 mg/g for **Z. spina**in the industrial area during the winter season, while the highest rate for chlorophyll was 4.69 mg/g for eucalyptus during the summer in the rural area.

Total chlorophyll (mg/g)	Summer			Winter		
	Rural	**Urban**	**Industrial**	**Rural**	**Urban**	**Industrial**
Conocarpus	4.69	4.55	4.28	4.12	3.45	3.11
Z. spina	1.60	1.54	1.52	1.51	1.43	1.02
E.tereticornis	2.28	2.12	2.08	1.98	1.78	1.60

PH

The lowest and highest rate in Eucalyptus and in Seder, pH rates ranged between 5.1 -6.9% in industrial and rural areas during summer and winter respectively

The results of the statistical analysis indicated that there were significant differences between the sites

Table(2) : PH rates in the selected plants in summer and winter

PH	Summer	Winter

	Rural	Urban	Industrial	Rural	Urban	Industrial
Conocarpus	5.69	5.54	5.10	5.23	5.57	5.19
Z.spina	6.60	6.54	6.52	6.91	6.43	6.02
E.tereticornis	6.83	6.51	6.64	6.81	6.78	6.60

Relative water content %

The lowest average water content was 59.80% for Seder during summer in the region industrial, while the highest rate was found at 86.13 % in eucalyptus in rural area during winter .

Table(3) : Relative water content (%) rates in the selected plants in summer and winter

Relative Water Content (%)	Summer			Winter		
	Rural	Urban	Industrial	Rural	Urban	Industrial
Conocarpus	85.42	79.02	79.80	86.13	83.12	79.44
Z. spina	60.62	59.95	59.80	60.29	60.15	60.14
E.tereticornis	79.83	75.72	72.64	81.89	80.78	80.60

Ascorbic acid

The lowest rate of ascorbic acid content of the eucalyptus plant was 4.34 mg/g in the rural area during the summer, while the highest rate was found in the Seder 7.28 mg/g in the industrial area during the summer.

Table (4) Ascorbic acid content (%) rates in the selected plants in summer and winter

Ascorbic Acid(mg/g)	Summer			Winter		
	Rural	Urban	Industrial	Rural	Urban	Industrial
Conocarpus	4.34	5.52	6.32	5.9	5.75	6.17
Z. spina	5.01	5.70	7.28	6.51	6.93	7.02
E.tereticornis	7.83	7.72	7.64	8.89	8.78	8.60

Air pollution tolerance guide

The lowest and highest rate of plants Seder and Conocarpus according to the air pollution tolerance index (APTI) values ranged between 11.09 - 14.99 during summer and winter in all regions (rate for each plant in all seasons and areas).

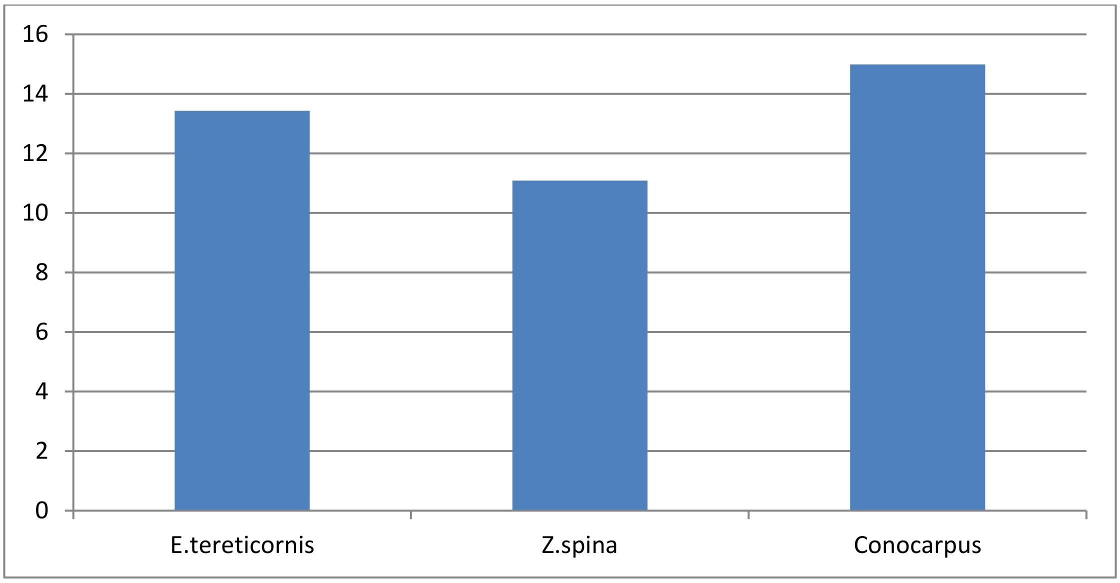

Figure (5) showing the air tolerance index of the plants under study.

APTI(Sidr) = 11.09

APTI(Conocarpus) = 13.43

APTI (Eucalyptus) = 14.99.

The APTI values for each plant in the three study locations ,calculated for summer and winter in table(4-5)

Table(5) : shows APTI values for the studied plants in each region in summer and winter

APTI	Summer			Winter		
	Rural	**Urban**	**Industrial**	**Rural**	**Urban**	**Industrial**
Conocarpus	12.00	13.47	13.90	14.20	13.49	13.6
Z. spina	10.16	10.60	11.83	11.51	11.46	10.95
E.tereticornis	15.11	14.39	13.92	16.00	15.59	15.11

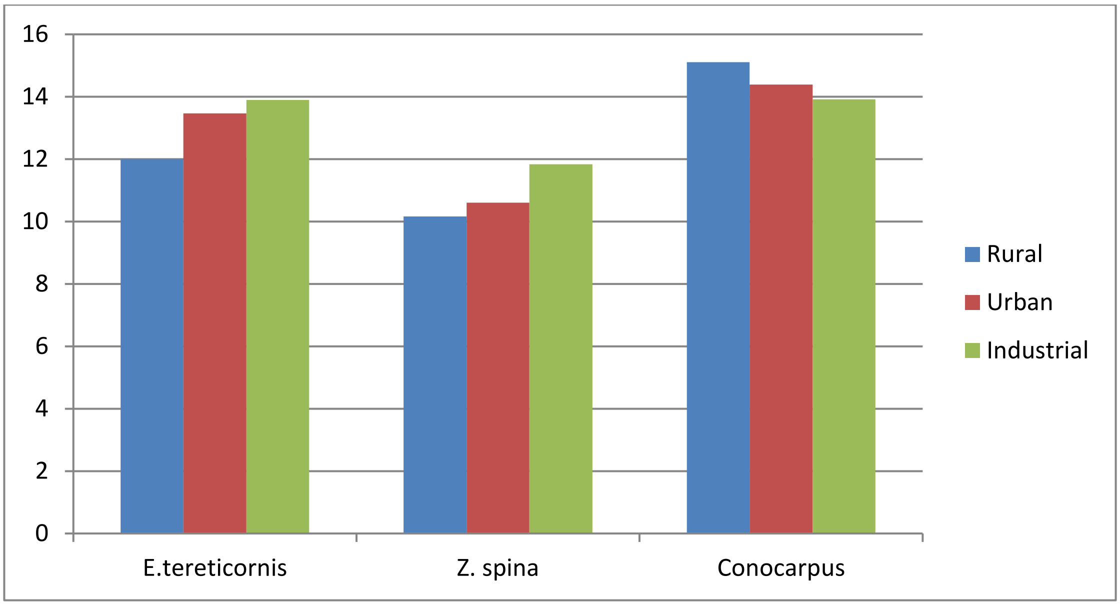

Figure (6) :APTI values for each plant in our studied regions in summer.

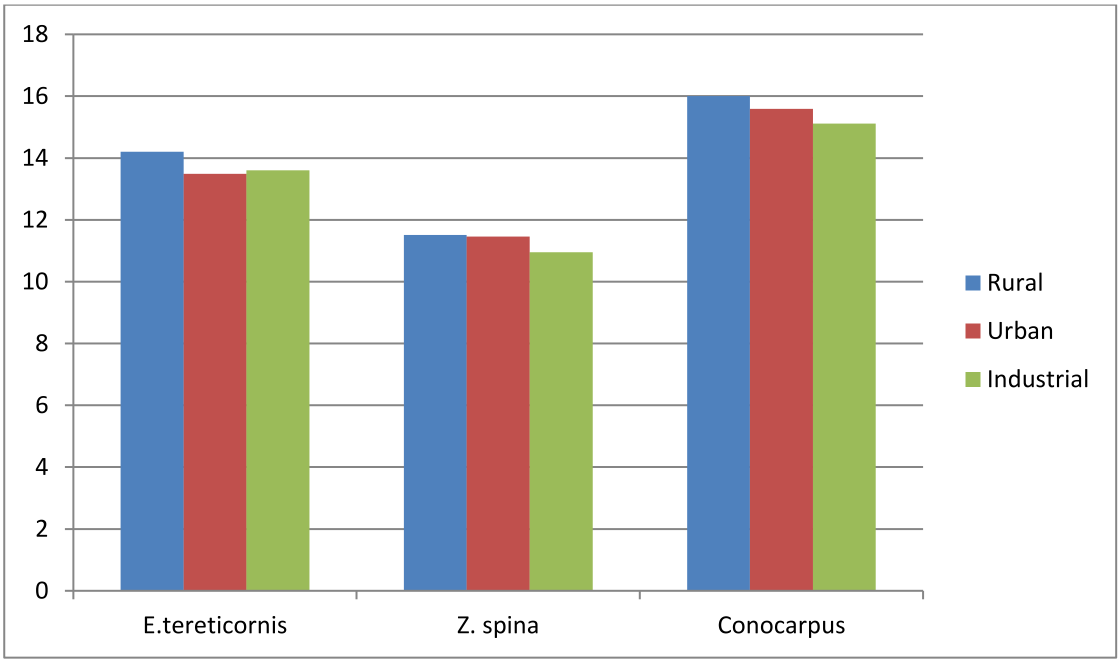

Figure (7) :APTI values for each plant in our studied regions in winter.

Table (6) Correlation factor between mean of APTI value to Ascorbic acid and relative water content and chlorophyll and PH

Mean APTI value	C.F. for A.A.	C.F.for TCH	C.F.for PH	C.F.for RWC
13.18	0.757237	0.292643	-0.14029	0.840913

Discussion

Dust

According to the current study results the industrial area had the highest rate of falling dust, less than the urban area, and the least were the rural area. The nature of industrial activity that forming a type of dust could be behind the increasing in dust ratio. Another cause the vehicles movement which can raise dust in unpaved streets (usually) with it.

In the other hand in city center the ratio decreases compared to the first area because the city has less activity than the industrial area, and the building height stops the dust movement. The vegetation cover acts as a natural bollards in the rural area which possess the least ratio in dust fall in this survey (Ter et al., 2020) .

The difference between months because of climate factors. This fact behind the increasing in raising dust and dust storms in March, April, May according to this survey and previous studies in Iraq(Al-Hasnawy, 2018). Total annual dust storm frequency is 23.57 days per a year ,so it forming about 6.5% from year days (Naser & Alkinani, 2017).

In summer the ratios of dust more than other seasons; especially in comparison with winter and autumn. The increasing of heat degree and wind speed effect positively on dust. When heat increases, it leads to evaporation ratio increasing ,and particles' weight decrease enables wind to raise it in the air (Aljoubori, 2013).

Comparison between the current study results and other studies in Iraq ,showed that the rate in Thi-Qar higher than that in Karbla' (36.74 g/m^2) (Al-Hasnawy, 2018), this is because of differences in climate factor and wind speed and rain rates between the two governorates, and the different geographical locations of the tow stations(Aljoubori, 2013).

Neighboring country; Kuwait in a study the rate of dust: in this station more than the result in Kuwait(53.00 g/m^2) (Al-Awadhi & AlShuaibi, 2013). Iran had the least between the previous studies (14.41g/m^2) (Malakootian et al., 2013).

Dust particles' size

The average size of dust particles were 16.47 micron , and this size dangerous for human health , because it is less than 100 micron (WHO, 2016). The minute size enable the particles to adsorb another pollutants , and thereby increasing the problem by the harmful, carcinogenic , inhalable, adherable particles (heavy metals recorded in this survey).

In the current study the dominant size in all study locations and all seasons was the size in 2-50 micron, this fact can explained as the source of dust in Thi-Qar is coming from west to the south of Euphrates river(Wilderson, 1991) . The prevalent rates recorded in summer this fact proves the origin of dust particle is coming from barren soil (Aljoubori, 2013).

The size of 50-100 and 100-250 micron ,heavy to be carried by wind and need very high speed wind to be portable, and wind in the study stations do not involve that type (100km/hr) (AL-Umar et al., 2019) .

Particles in 2 micron and less were very little because the minute dust particles tends to aggregate with each other, in addition to the difficulty of collecting this fin size. This study result comes in accordance with study in Karbala (Al-Hasnawy, 2018) .

Biochemical analysis of study plants

Chlorophyll content

The chlorophyll rates in the rural station more than in urban and industrial stations. In general the rates are low in this survey, this is considered as indicator for pollution(Ninave et al., 2001).

This result confirm the previous result in this survey about collected dust and the suspended materials on the dust particles(Ld, Cd).

Accumulation of dust particles on plant leaves prevent light from reaching plastids, effecting on photosynthesis process. In addition the dust closes the stomata pores ,thereby harming the plant by stopping gas exchange and plant respiration, and also effecting negatively in metabolism (Bharti et al., 2018).

This facts explain the yellow color of the leaves collected from industrial station. The highest rate in Eucalyptus, this indicating the plant's ability to tolerate the pollution. In opposite the Sidr which had the lowest rate in this survey, so it has the lowest tolerance between the chosen plants in this survey.

Power of Hydrogen (PH)

The plants that have high ph have the ability to convert glucose to ascorbic acid ,which is an antioxidant can be active in stress conditions(Laurent et al., 2014).

In opposition the low PH indicate sensitivity of the plant to the air pollution. Accumulation of dust particles prevent plant respiration leading to increased CO_2, and the last converted –in high concentration to carbonic acid, thereby the PH decreases.

The study's result comes in accordance with studies in polluted areas; and the PH were low. Previous study in Babylon found the same relationship between pollution and PH in plants (Salaa & Al-Kawaz, 2017).

Relative water content

The water content in plants of the rural area is the highest rate in comparison with other study areas -urban and industrial- and the water is very important in all physiological processes happened in the plant(Innes & Haron, 2000).

The water content varies from plant to plant, depending its structural and physiological nature. Some plants keep water in stressing environment. In the other hand the fall dust on stomata prevent inspiration, causing water low concentration (Youguang & Tan, 2013).

In same direction with this study results – low water content in polluted area- the sudy in Karbala (Al-Hasnawy, 2018) and in in Iran(Gholami et al., 2016).

Ascorbic acid

An important antioxidant compound has a strong ability for free radicals inhibition, and so it plays important role in air pollution tolerance(Smirnoff et al., 2001).

Increased concentration of ascorbic acid in industrial and urban area indicating air pollution in that places, compared to rural area. The ascorbic acid formation depend on PH, so low PH prevent converting glucose to ascorbic acid (Laurent et al., 2014).

Air Pollution Tolerance Index(APTI)

Air pollution tolerance index calculated depending on chemical indicators (PH, relative water content, ascorbic acid, and chlorophyll content). APTI value is useful method in classifying plants toward air pollution, and predicting air quality (Singh et al., 1991).

The values of APTI ≥17 : tolerant .

APTI(12-16): moderate tolerance .

APTI≤12 sensitive to air pollution.

The same plant may be tolerant in a place but sensitive in another place that because the value of APTI depend on many calculated indicators differing in the seasons. According to correlation coefficient there is a strong positive relationship between ascorbic acid and APTI value(C.F.= 0.757237).Relative water content has a positive relationship too(C.F.=0.840913).

Conclusions

1- The great effects of air pollution on increasing health challenging problems, increasing asthma and cancer.

2- The portable materials carried by dust particles increase the danger of air pollution dimensions.

3- Eucalyptus is good tolerant in Thi-Qar governorate, and the Seder is sensitive in this study.

4- The industrial area is the most polluted area –from the three area of the study- and the rural is the least between the study stations.

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