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DETERMINATION OF HEAVY METAL ACCUMULATION IN SOME LANDSCAPE PLANTS

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THESIS CONFIRMATION

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COMMITMENT

All information in this thesis have written according to the ethical behaviour and academic regulations of Kastamonu University, in addition what does not belong to me in this study was prepared in accordance with the rules of thesis in Kastamonu Uinversity, all kinds of statements and reports writing that fully referenced to the source of knowledge and commitment.

Elnajı A. Ahmaıda SALEH

ÖZET

Doktora Tezi

BAZI PEYZAJ BİTKİLERİNDE AĞIR METAL BİRİKİMİNİN BELİRLENMESİ

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Hava kirliliği günümüzde kentsel alanların en büyük sorunlarından birisidir. Hava kirliliği bileşenleri içerisinde ise ağır metaller ayrı bir öneme sahiptir. Zira ağır metaller doğada bozulmadan uzun süre kalabilmekte and çevredeki konsantrasyonu da sürekli artmaktadır. Ayrıca biyobirikme eğilimindedir. Bundan dolayı ağır metal konsantrasyonunun belirlenmesi, riskli bölgelerin and risk düzeyinin tespit edilmesi açısından büyük önem taşımaktadır. Havadaki ağır metal konsantrasyonunun belirlenmesinde biomonitor olarak genellikle bitkiler kullanılmaktadır. Bitkilerdeki ağır metal konsantrasyonlarının belirlenmesi, hem bitkilerin ağır metalleri havadan uzaklaştırma and dolayısıyla hava kalitesini artırma aracı olarak kullanılabilme olanaklarının belirlenmesi, hem de hava kalitesinin izlenmesi açısından önem taşımaktadır. Bu çalışmada trafik Heavyluğunun farklı düzeyde olduğu alanlardan toplanan bazı peyzaj bitkilerinde, farklı ağır metal konsantrasyonlarının trafik Heavyluğuna bağlı olarak değişiminin belirlenmesi amaçlanmıştır. Bu amaç doğrultusunda, peyzaj çalışmalarında sıklıkla kullanılan *Salix babylonica, Tilia tomentosa, Eleagnus angustifolia, Robinia pseudoacacia, Sophora japonica, Prunus cerasifera, Ailanthus altissima and Aesculus hippocastanum*'un, trafiğin Heavy olduğu, Low dense olduğu and hemen hemen hiç trafik bulunmayan alanlarda yetişen bireylerinden yaprak örnekleri toplanmış and ağır metal analizi yapılarak Pb, Cu, Ca, Mg, Cd, Cr, Ni, Fe, Mn and Zn miktarları belirlenmiştir. Çalışma sonucunda; trafik Heavyluğuna bağlı olarak Cu, Cr, Fe, Mn and Zn değişiminin belirlenmesi için en uygun türün *Sophora japonica* olduğu belirlenmiştir. Bunun dışında trafik Heavyluğuna bağlı olarak meydana gelen değişimlerin izlenmesinde, çalışılan türler içerisinde en uygun türlerin Pb için *Prunus cerasifera,* Mg için *Ailanthus altissima,* Cd için *Eleagnus angustifolia,* Ca and Ni için ise *Robinia pseudoacacia* olduğu belirlenmiştir.

Anahtar Kelimeler: Bioindikatör, ağır metal, trafik yoğunluğu, bitki

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ABSTRACT

Ph.D. Thesis

DETERMINATION OF HEAVY METAL ACCUMULATION IN SOME LANDSCAPE PLANTS

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Air pollution is one of the biggest problems of urban environments today. Heavy metals are particularly important in terms of components of air pollution. Because heavy metals can stay in nature for a long time without being disintegrated, and their concentration in the environment is constantly increasing. They also tend to bio-accumulate. Therefore, determination of the heavy metal concentration is crucial for identifying high-risk areas and the level of risk. Plants are generally used as bio-monitors for determining heavy metal concentration in the air. Determination of heavy metal concentrations in plants is crucial in determining the ability of plants to remove heavy metals from the air, and thus being used as a means of increasing air quality, as well as monitoring air quality. The aim of this study was to determine the variation of different heavy metal concentrations depending on traffic density in certain landscape plants collected from areas where traffic density is at different levels. For this purpose leaf samples of Salix babylonica, Tilia tomentosa, Eleagnus angustifolia, Robinia pseudoacacia, Sophora japonica, Prunus cerasifera, Ailanthus altissima and Aesculus hippocastanum, which are frequently used in landscaping studies, were collected from individuals where there was dense traffic, less dense traffic, and almost no traffic, and the quantities of Pb, Cu, Ca, Mg, Cd, Cr, Ni, Fe, Mn and Zn were determined by heavy metal analysis. As a results of the study, it was determined that Sophora japonica is the most suitable for determination of the exchanging of Cu, Cr, Fe, Mn and Zn depends on traffic density. In addition, it was determined the most suitable species among the species studied in the course of monitoring the changes occurring due to traffic intensity are Prunus cerasifera for Pb, Ailanthus altissima for Mg, Eleagnus angustifolia for Cd, and Robinia pseudoacacia for Ca and Ni, respectively

Key Words: Bioindicator, heavy metal, traffic density, plant

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Elnajı A. Ahmaıda SALEH
Kastamonu, May, 2018

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INDEX OF ABBREVIATIONS

Al	Aluminum
As	Arsenic
Hg	Mercury
Co	Cobalt
Pb	lead
Cr	Copper
Ca	Calcium
Mg	Magnesium
Cd	Cadmium
Ni	Nickel
Fe	Iron
Mn	Manganese
Zn	Zinc
CO_2	carbondioxide
t	ton
m	meter
O_2	oxygen
°C	santigrat
mm	millimetre
kg	kilogram
μm	milimikron
ppb	part per billion
ppm	part per million
F	F value
$\mu g g^{-1}$	mikrogram / gram
$t\ yr^{-1}$	ton / year
$t\ ha^{-1}$	ton / hectare

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1. INTRODUCTION

The increasing urbanization rate in the last century has caused population density especially in metropolitans, and the number of people living in the unit area has been increasing rapidly. It is foreseen that while less than half of the world's population were living in urban centers in 2000, this ratio can rise up to 90% in 2030 (Şevik et al., 2017). Today, more than two-thirds of the total population in European countries live in urban areas. According to the data of the Address-Based Population Registration System of Turkey Statistical Institute; the proportion of people living in centers of cities and provinces rose to 92.1% in 2015, while the proportion of people living in towns and villages was 7.9% (URL-1, 2015). At the same time, the migration from the village to the city is still going on and it is predicted that the population of the cities will increase further in the future (Çetin et al., 2017).

The increasing urban population has brought many problems together. Perhaps the most important one of these problems is air pollution. Air pollution can be described as the existence of one or more pollutants in the atmosphere in quantities and duration which can be harmfulbe harmful for human, plant and animal life, commercial or personal property and the quality of the environment (Müezzinoğlu, 1987). Every year thousands of people are affected by air pollution, and millions of people around the world lose their lives due to air pollution. Because of the intensification of air pollution in urban centers, it poses a great risk especially for people with various health problems (Isinkaralar et al., 2017). Today, air pollution has become one of the most important problems of the modern society and it is reported that about 6.5 million people lose their lives due to air pollution every year in the world (Isinkaralar et al., 2017). Although air pollution is not seen as a major problem in Turkey, it has been reported that 29 thousands of people have lost their lives because of the reasons related to air polution only in 2016 (URL-2, 2016). Air pollution is a bigger problem especially for children, old, pregnant and sick people who are in risk groups in terms of health (Işınkaralar et al., 2017).

The heavy metals in the components of air pollution have a separate significance. Heavy metals do not deteriorate in nature and do not disappear. They also tend to bioaccumulate. Therefore, the determination of the heavy metal concentration has great importance in determining the risk areas and the level of risk (El Hasan et al., 2002). There are numerous studies that show that heavy metal pollution in the atmosphere has significant effects on human health. In 1952, 4000 people died from airborne damage to respiratory systems of heavy metals, and samples from victims were found to have high levels of heavy metals such as Pb, Zn and Fe in their lungs (Shadid et al., 2017). For this reason, the determination of the amount of heavy metal is of special importance.

Plants are frequently used as biomonitors to monitor the heavy metal concentration in the air. Many species, such as *Aesculus hippocastanum, Betula pendula, Platanus orientalis, Fraxinus excelsior, Tilia tomentosa* and *Elaeagnus angustifolia*, are used as biomonitories of traffic-induced air pollution (Tomasevic and Anicic, 2010; Petrova et al., 2014; Ozturk and Bozdogan, 2015).

Plants are frequently used to monitor heavy metal accumulation, especially caused by industrial or traffic sources. In addition to being used as biomonitors, plants also perform many functions. Plants reduce the noise in the environment they are in (Aricak et al., 2016), enable psychologically positive effects (Cetin, 2015a, b), reduce the energy consumption (Cetin, 2015c), they are an important economic resource (Sevik, 2011; Sevik, 2012; Tunçtaner et al.), they prevent erosion (Özel et al., 2011; Sevik et al., 2016a), reduce the speed of the wind, keep the soil with its roots, prevent rainfall and rivers to remove the land, protect wild life and hunting resources. And also the open green areas where the plants are located are important activity areas for both adults and children (Çetin and Şevik, 2016b, Özel and Ertekin, 2012).

In addition to these functions, plants are also very effective in reducing air pollution (Sevik et al., 2017). Plants perform photosynthesis in environments where light and temperature conditions are sufficient in their natural life processes. They use the air in the environment for photosynthesis by their leaves through their stomas, and use

CO2 in photosynthesis, so they reduce the amount of CO2 in their environment. Oxygen is essentially the result of the photosynthesis, which occurs by plant metabolism, and in a small amount, the decomposition of water vapor in the atmosphere. The atmospheric oxygen is calculated as 1.18 x 1015 t. The annual net oxygen production of all plants in the world is 70 x 109 t and the atmospheric oxygen is renewed in every 17000 years. The amount of oxygen used in biological processes and given to the atmosphere is almost the same, with very little production. However, the destruction of the fossil fuels and the destruction of the vegetation cover has destroyed a great deal of potential oxygen. In this way, the total amount of carbon dioxide given to the atmosphere is 10 billion tons, equal to the consumption of 8 billion tons of oxygen, and this amount is not recycled (Önder and Polat, 2012).

Measurements committed in Frankfurt showed that the amount of atmospheric oxygen in a park is 18% and that in a tree-lined street is 17%. Notwithstanding the fact that the total amount of oxygen in the atmosphere has fallen does not attract much attention. The billions of tons of oxygen found in the upper layers of the atmosphere can not be used at altitudes of 50-100 m above ground level. It is not the case that green areas in a city produce as much oxygen as consumed in a city. However, green areas and trees play an important role in the increase of the amount of respirable oxygen in this area during stagnant weather where the upper layer oxygen can not be transported to the lower layer where the respiration takes place. Briefly, the open and green spaces in the city centers have important effects on the breaking the hot spots in cities and lead the clean air into the city rather than the fact that the plants in these areas produce O2 (Sevik et al., 2016b).

Nevertheless, it is known that plants have significant contribution on reduction of CO2 in the environments that they exist intensely. According to a study about the role of trees in CO2 reduction, 6 million trees in Sacramento (California USA) remove about 335.199 tons of atmospheric CO2 per year. The amount of monetary equivalent of this amount is equivalent to 3.3 million dollars per year (Önder and Polat, 2012).

Besides, the air entering the plant is emerging as being cleaned from many respects. The studies suggest that plants remove many pollutants from their environment sauch as carbon monoxide (CO), particulate matters, volatile organic compounds (VOC), ozone and heavy metals in addition to carbon dioxide (CO_2) (Aksoy et al., 2000; Beckett et al., 2000; Islam et al., 2012; et al., 2013, Papinchak et al., 2009; Zadeh et al., 2013; Papinchak vd., 2009)

Plants also play an important role in air filtration in the environment they are in. It has been understood that trees and green areas play an active role in air filtration from tests on wind curtains and the tests that are directly related to the subject. There is no dust formation except the pollen in the vegetation-covered areas. Trees primarily reduce the carrying capacity of the air to provide storage of particulate matter. By forming a wind curtain or vegetative wall, the trees in the parks filter 85% of the particulate matter and the trees on the street filter about 70% of the particulate matters in their environment. Even in the winter months when the plants are leafless, the trees maintain 60% of their effectiveness on this subject. Trees can hold dust up to 5-10 times heavier than their leaves. According to a study committed in France during five years, an area without trees in Paris had an average of 3910 bacteria in $1m^3$ of air, and it fell to 455 in a nearby park. It is estimated that the tree cover in New York (USA) in 1994 contributed $ 9.5 million by removing 1,821 tons of air pollutants from the atmosphere(Önder and Polat, 2012).

Particulate matter is one of the most important parameters for air pollution. The adverse effects of air pollution due to particulate matter on human health have long been known. As a result of these adverse effects, there are serious increases in rates of lung cancer, chronic asthma attacks, COPD, chest diseases, upper respiratory tract diseases, damagse on eye, nose, throat and death. In addition, heavy metals accumulate on the particulate matter (Okcu vd., 2009).

Heavy metals are perhaps the most important pollution factors. In fact, metals naturally comprise and some are real pieces of global ecosystems. Some heavy metals are important micro-elements for plants at low doses; but high doses prevent most plant species from growing and may cause metabolic disturbances (Okcu et al., 2009). When the heavy metal concentration is monitored, plants are frequently used as biomonitor (Tomasevic and Anicic, 2010; Petrova et al., 2014; Ozel et al., 2015; Ozturk and Bozdogan, 2015).

The quality of life in urban areas and the visual and aesthetic value of the environment in which people live is being tried to be improved by using plants in and around the city considering the environmental and social benefits (prevention of air pollution, noise, erosion etc.) of plants (Tilki et al., 2008). Plant assets in urban centers are considered as a sign of urban quality and human livability (Çetin, 2016).

In addition to the ecological, economic and social benefits of plants, it is known that they help to improve air quality and reduce air pollution (Sevik et al., 2017). However, not every plant has the same effect on removal of heavy metals, which have a separate significance in air pollution . Studies conducted up to this day reveal that different plants have different levels of potential for accumulating different heavy metals. The only way to enable the plants to be used effetively both as biomonitors and to remove the heavy metals from the air is to determine which plants have a high tendency to accumulate heavy metals and which heavy metals accumulate on which plant species.

In this study, it was aimed to determine the variation of different concentrations of heavy metals depending on traffic density in some landscape plants collected from areas where traffic intensity is at different levels. Within the study, leaf samples were collected from *Salix babylonica, Tilia tomentosa, Eleagnus angustifolia, Robinia pseudoacacia, Sophora japonica, Prunus cerasifera, Ailanthus altissima and Aesculus hippocastanum* species on areas where the traffic is heavily dense, less dense, and on pedestrian zones where there is no enterance for any vheicles at least 50m away from the sample trees. The analysis conducted on these leaf samples were aimed at determining the amount change of Pb, Cu, Ca, Mg, Cd, Cr, Ni, Fe, Mn and Zn elements.

1.1. General Characterıstıcs Of The Sample Plants

The species of *Salix babylonica, Tilia tomentosa, Eleagnus angustifolia, Robinia pseudoacacia, Sophora japonica, Prunus cerasifera, Ailanthus altissima* and *Aesculus hippocastanum* that are used frequently in landscape desings were chosen as the sample plants of the study. General characteristics of the species thar are subjected to this study are given below;

1.1.1. *Tilia tomentosa*

Tilia tomentosa Moelch. (lime tree) naturally spreads from North America to Mexico in every region in the temperate regions from Europe to Asia and Japan (up to 65 latitude) (Tamtürk, 2013). It was determined that this species has been seen in Southeast Europe, Southwest Asia, in east of Balkans in Turkey, Hungary, and Europe particularly in Former Yugoslavia, Bulgaria, Romania, and in Greece. It has been seen spreading on the flat peaks of Bulgaria. In our country, it spreads between beech, chestnut, hornbeam and oak forests in Western Black Sea and Marmara Region forests (Birbilener, 2015).

There are about 40 known closely related species of the family Tiliaceae, with about 400 species identified. Generally, many of the species are in tree form. It was determined that there are 2 genus of 5 species in Turkey. There are 17 species of lindens found in East Asia, 6 species in Europe and one species in North America. The species belonging to the genus Tilia are highly important economically and ecologically. The identified species of this genus are; *T. americana*, *T. amurensis, T. chinensis*, *T. chingiana*, *T. cordata*, *T. dasystyla*, *T. henryana*, *T. heterophylla*, *T. insularis*, *T. intonsa*, *T. japonica*, *T. kiusiana*, *T. mandshurica*, *T. maximowicziana*, *T. miqueliana*, *T. mongolica*, *T. nobilis*, *T. oliveri*, *T. paucicostata*, *T. platyphyllos*, *T. rubra subsp. caucasica*, *T. taquetii*, *T. tomentosa* and *T. Tuan*. The species identified to spread in Turkey are; *T. tomentosa Moench., T. cordata Miller, T. platyphyllos Scop., T. rubra DC subsp. caucasica (Rupr)* (Birbilener, 2015).

Lindens (especially *Tilia tomentosa* and *Tilia platyphyllos*) have the ability to make large diameters and height in suitable growing areas in mountainous valleys and similar areas with warm climatic conditions. In young trees, the trunk shell is light gray in color and thick grooved in the longitudinal direction. As the tree ages the color of the trunk gets dark gray or black cracked (Ebcın Korkusuz, 2014). (Photograph 1.1.)

Photograph 1.1. Tilia tomentosa stem

Silver linden; prefers the limy soils that are permeable, light and generally damp during the summer, and deep soils, slightly moist and rich in nutrients. The silver linden exist in Turkey along the Black Sea region where there are plenty of rainfall and on the West Anatolian mountains at lower altitudes. Because of its strong stooling capability, it is a suitable species for the formation of marshy and horticultural forests (Ebcın Korkusuz, 2014).

T. tomentosa is a plant which can height up to 20 to 35 meters, deciduous and has a woody structure with a bushy form in some species, but usually in the form of a tree. It has a capability of growing rapidly. While it has a pyramidal form at a young age, it gets an oval shape in the following years. The lobulated leaves are in the form of a heart. The upper surface of the leaves are green and covered with villus. The lower face is more furry than the upper face. There is an asymmetrical leaf base. Leaf edges are pointed and their edges are toothed. There are two atria in the part where the leaf stalk meets the branch (Birbilener, 2015). There are also villus on the leaf stalks, but these villus drop later and shoots are reddish brown and olive green. The branches separate from the body by a narrow angle. It is a tree species that have thick branches. The flowers appear to have a layered structure due to the staminos they carry. The pendulous simoz flower boards consist of 7-10 flowers. The brahtes are also covered with villus. Flowering begins in the beginning of June and July. Flowers are fragrant and yellow in color (Photograph 1.2.) (Tamtürk, 2013).

This species is used in urban areas that have heavy traffic and in industrial zones to reduce the noise that has reached to a disturbing level currently. The linden tree should be used frequently in urban areas as it has a high capability of shade (Tamtürk, 2013).

Photograph 1.2. *Tilia tomentosa* tree form (URL-3, 2018)

1.1.2. *Elaeagnus angustifolia* L.

Elaeagnus angustifolia L., is a useful plant belonging to the family *Elaeagnaceae,* from the group of *Magnoliophyta*, from the class of *Magnoliopsida*, from the group of roses (*Rosales*) (Kalyoncu, et al., 2008).

It is known that this plant has about 10 species spreading in the geographical region of Europe, Asia and North America. *Elaeagnus angustifolia L.,* of which only the types that are produced by cultivated forms are named silverberry, the naturally growing forms are named as hippophae, has natural spreading in Turkey (Gülcü and Çelik Uysal, 2010). This species spreads in the middle and western regions of Asia, in the Gobi Desert, in the Alps, around Mediterranean regions and in the Black Sea, Marmara, South Anatolia and South East Anatolia in our country (Göktürk et al., 2007).

Its vertical spread can be up to 3000 meters above the sea level. This species that has the ability to develop a strong side roots that shows rapid growth characteristics compared to other tree species and has nodules on these roots that can improve soil conditions by binding free nitrogen of the air (Göktürk et al., 2007). As it can be evergreen in all periods of year, it also has deciduous bush and tree forms (Gülcü and Çelik Uysal, 2010). The silverberry, which has sharp and beautiful fragnant flowers, can height up to 7-8 meters. The leaves of this semi-shade species, are 4-8 cm long, lance shaped, flat edged, narrow blunt and pointed. Thick and crunchy thorny shoots begin to bloom in June (Photograph 1.3. , Photograph 1.4.). The seed is in the fruit, and is 5-10 mm long with an oval pointed shape. Each fruit has a single seed. The production is carried out by semi-mature cuttings obtained in greenhouses in summer or by wood cuttuings or immersion at the end of winter and autumn (Kalyoncu, et al., 2008).

Photograph 1.3. *Elaeagnus angustifolia* L. flower form

Photograph 1.4. *Elaeagnus angustifolia* L. Tree form

It prefers light sandy and fertile soil (Kalyoncu, et al., 2008). The silverberry is also a very abstinent species in terms of soil needs as it can even grow up well in shallow, dry and arid, poor, calcareous and salty soils (Göktürk et al., 2007).

The species of Eleagnus is a very valuable plant for our country as they have a characteristic of soil protection and they can heal degraded soils (Göktürk vd., 2007). As its fruits have more carbohydrates, proteins, organic substances, amino acids and vitamins than many other nutrients, it is also an important species for the wild life (Gülcü and Çelik Uysal, 2010). As well as its benefits for wild life, this species also used for erosion control and alle plantations.

Although it has an important contribution on erosion control which is a struggle in our country for a long time, it has been ignored and has not been studied appropriately yet. Due to the characteristics of this plant mentioned above, it is possible to use it for the plantation of arid and semi-arid areas (Gülcü and Çelik Uysal, 2010).

In addition to these characteristics, it has been documented in Asia and Europe that it is also used in medicine and pharmacy, and it is known that the first medical experimental studies on silverberry started in Russia in 1950. As it is a very resistant species towards disease and insect damages, it is frequently prefered on street side planlations in Europe and America (Gülcü and Çelik Uysal, 2010).

1.1.3 *Prunus cerasifera* Ehrh

Plum is a species with a wide spreading range among the all the fruit species cultivated in the world geography. The plum, which has various species, can be grown under different climate conditions and on different area types (Özkarakaş et al., 2006). It has been known for long that the plum spread over all other Mediterranean countries starting from small Asian countries and now has a large spreading area.

Most researchers state that the spread area of the plum is between Black Sea and Central Asia. In Italian the plum is called “susina” and it is stated that this can originate from the city of “Susa” in the Elam territory of Persian Empire (Özkarakaş and Ercan, 2003).

It has been reported in the sduties which adress the the origins of plant species that the origins of plum species have been found in Anatolia too. Turkey is as the genetic centeral of this identified important plum species of *Prunus cerasifera* Ehrh., *Prunus institia* L. and *Prunus spinosa* L. In addition to these plum species, important cultivated forms obtained from *Prunus domestica L.* and *Prunus salicina L.* are also grown in our country (Özkarakaş et al., 2006).

Various studies have been carried out on the cultivation of *Prunus cerasifera* (green plum) which has a very wide population in our country. There are four types of plum cultivated of this species. These are “Papaz, Can, Havran and Kebab” types. There is a wide variation among the cultivated plum cultivars. The plum species has a wide variety of genres and hybrids. Because of this reason, the species has a wide range of morphological characters (Özkarakaş et al., 2006).

Prunus cerasifera cv. 'Pissardii Nigra' (ornamental plum) has red small fruits that can be eaten like other types of plums of the *Prunus* genus. It is a species that can height up to 9 meters avarage due to its morphological characteristics, and is a decidous plant with a rounded crown and has reddish leaves with pleasant appearance. The leaf stalk of the plant is bright red and the leaves are reddish-green (Photograph 1.5). It can be seen that the flower boards exist in single or groups on the tree and the outer side has a pinkish color towards the white middle parts (Photograph 1.6.). It has thick branches that blooms before the leaves begin foliation in the spring. In terms of fruit, it has a round, fleshy, sour and bright dark red fruit. *Prunus cerasifera* is widely preferred in landscape designs. *Prunus cerasifera*'s economical prosperity is increasing day by day as it has been highly on demand through landscape architects. It has started to be widespreadly used among people as a medical plant as it has been good for various diseases. (Kırbağ and Göztok, 2016).

Photograph 1.5. *Prunus cerasifera* Ehrh tree form

Photograph 1.6. *Prunus cerasifera* Ehrh flower and leaf form

1.1.4. *Ailanthus altissima*

The origin of *Ailanthus altissima* is China. The definition of this plant in Europe was in the year of 1740, and 1751 in America. Currently it spreads from the Mediterranean to the north of Central Europe. The other name of *Ailanthus* is known as the "heaven tree". The reason of calling this species as the heaven tree is that Israel used this plant on desert plantations. The family of this species is known as *Sımaroubaceae,* belonging to *Sapindales* order, from the class of *Rosidae* (Bardak, 2014).

Ailanthus had been used as a park and garden plant due to various characteristics of the plant for a long time. Rapid growth, ostentatious and colorful leaves, impressive fruit characteristics are just a few of them. But later, the usage of this plant decreased because of some disadvantages of this plant such as its spreading allelophilic chemicals and due to its invasive nature, and not letting any other plant species to survive around it, and the bad smell of leaves, fruit and wood. *Ailanthus* is very resistant to hot and cold weather conditions, salty water, acid rain and polluted weather in cities (Bardak, 2014). Although optimal growth temperature of this plant has been determined as 7-18 ° C, it has been observed to live up to -35 ° C (Turkey

Invasive Plants Catalog, 2015). It can survive in highway edges and other polluted areas where other plant species can not survive or try to adapt in unhealthy conditions due to its resistance to air and soil pollution. Beside these areas it also likes the sides of rivers and streams and pebbly soils, but it best grows in loose and deep soils. It is a species that has high temperature and light demand. At early ages, saplings may suffer damage from frost (Bardak, 2014).

Ailanthus altissima can reproduce themselves intensively after forest fires. It can generate sexually or asexually. It has a high capability of giving stool and log shoots. It can be produced by seed and root cuttings. It is a short-lived species that can last 40-50 years. It must be under control to prevent the undesirable results on the areas of production as it grows and generates really fast. It can height up to 15 meters in 25 years, and 30 meters in 50 years with 1 meter of trunk diameter. As it is encountered in almost every region of our country, it has been spread by the people in the Eastern Black Sea Region where this species can be seen at the altitudes of 0-400 meters. It is determined that this plant species can also adapt to different altitudes (Bardak, 2014). It has been reported to survive in regions having up to 2400 meters altitude (Turkey Invasive plants Catalog, 2015).

It is a wide crowned tree that stay green during summer but is a decidous tree and the leaves fall in winter. It can height 50-80 cm per year. The maximum diameter that its trunk can grow up to is 1 meter. While the bark structure is plain and light gray at young ages, thin cracks can form on the aging tree. The branch form is smooth and light or dark gray in color, and as it gets older, cracks can grow on the branches as well as in the bark of the trunk. The single compound leaves carry 15-35 leaflets shaped like a spear and is 40-50 cm tall. The fronts of the leaflets are flat-edged, and the upper surfaces are coarse toothed towards the bottom, and the upper surface is green, while the bottom faces are dark green. The wends that cause the bad smell are at the bottom of the leaflets with 3-7 cm lenght and 2-3 cm width(Photograph 1.7.) (Bardak, 2014).

Photograph 1.7. *Ailanthus altissima* bush form

On the tips of the shoots, the blossoms, which are in the form of united clusters, have a combination of female and female flowers. Petals and seals are of 5 pieces. The petals are yellowish white. Fruits are winged, 3-4 cm in length, and 4-5 cm in width and are in the shape of thin strips. The seeds are located in the center part of the fruit. The self-beams can be clearly visable and the annual rings are very wide (Photograph 2.8.) (Bardak, 2014).

Photograph 1.8. *Ailanthus altissima* leaf and seed form

1.1.5. *Salix babylonica*

Salix babylonica L. is a plant belonging to angiospermae group of *(Magnoliophyta)*, class of (*Magnoliopsida)* and *Salicaceae* family of (*Salicales)* order (MEGEP, 2007).

Geographical spread of this species is in the southern regions of Asia (MEGEP, 2007). It has spread from its native land China to every part of the world (Özay, 1997). There are about 300 taxons spreading in the world while there are 24 taxons in our country. It is difficult to determine their systematics because they can easily be hybridized with their own species and they have numeorus taxons. The most common species in our country are *Salix alba*, *Salix babylonica*, *Salix caprea*, *Salix fragilis*, *Salix cinerea* and *Salix viminalis*. Many species of this plant are grown as ornamental plants in parks and gardens (Bıçakçı et al., 2014).

Salix is a decidous wooden plant species that can both be seen bush and tree form. It has a capability of heighting up to 10-15 meters (Bıçakçı vd., 2014). It is a tree that has a pleaseant apperance with a floppy form that can stay green throughout the summer season. It has thin, long and floppy branches. The floppiness of the shoots and branches is due to the elasticity of their branches (Özay, 1997). Young shoots are covered with gray-colored villus. Narrow leaves are 8-16 mm in length, in the form of strips or spears, short stemmed, with upper face dark, lower face pale green in colour (Photograph 1.9.) (Özay, 1997). The flowers boards are in the shape of spica, yellowish-white in colour. It gives early shoots with the arrival of spring and starts to bloom between March and April (MEGEP, 2007). Male and female flowers locates on different trees. It is usually pollinated by insects. There are many small seeds in the capsule-shaped fruit. The outer surfaces of the seeds are covered with velvety white villus (Bıçakçı et al., 2014).

Seeds begin to spread out in May-June. With the spreading of the seeds, a cottony appearance surrounds the trees. The villus seeds, mixed with pollen by many people because of its cottony appearance, are composed of flowers on the female tree (Bıçakçı et al., 2014).

Photograph 1.9. *Salix babylonica* tree form

It is a plant species that is very suitable for water edges. It is sensitive to frost. It can grow in cold and humid areas. Because of this characteristics of the plant, it is frequently preferred due to the aesthetic appearance of their shoots around the water items in parks and gardens (Karaca and Kuşvuran, 2012). It prefers deep, cool, moist and clayed soils. It can also easily grow in soils in the salty and coastal regions. It is a prunning friendly tree. It improves a flat root system. The production is made with cuttings taken in November-February (MEGEP, 2007).

1.1.6. *Robinia pseudoacacia*

Robinia pseudoacacia L. is known to have about 20 species which spreads between 35-43 degrees latitudes in North America and Mexico. It can make its geographical vertical spread up to 1,100 meters. While spreading naturally, it spreads as individual or in groups. This species which can height up to 25 meters can live up to 100 years. Acacia, which has begun to spread in Europe in XVIIth century, came to Turkey at the same time of the announcement of republic. This speciesis planted mostly on the sides of the roads and railways, in school and barracks gardens in our country. For these reasons, it is also known as the Republican tree in our country (Keskin, 2007).

It is estimated that this plant species was brought to our country by foreign companies, which came to build the railway at the time of the Ottoman Empire, and were used with the aim of preventing erosion in filling areas on slopes along the railways and around the stations. The first sapling of Acaia was produced in the nursery that was estimated in the Belgrad Forest in Istanbul, and was used for the plantation of Ankara Atatürk Forest. Among the leafy tree species of which are the subjects of plantation and stand establishment studies, the Acaia comes in the third order after eucalyptus and hybrid poplar. Acacia can spread almost in all geographical regions of our country horizontally. The species of Acacia, which can reach quite high levels in its vertical spread, has reached a height of 900 meters in the North Anatolian Mountains and in the Eastern Black Sea regions and is growing rapidly in these altitudes. It is also predicted that it can reach to higher altitudes, but it is predicted that as the higher it goes, the more slow the growing will get (Erkan, 2012).

It can be stated that Acaia is one of the most preferred species in the plantation works that has gained speed by the estimation of The Ministry of Forestry and the General Directorate of Plantation and Erosion Control.

The outer bark of Acacia has a flat structure at young ages with a lenticular-covered appearance. In elderly individuals, body shell is thick, deeply cracked, and gray-brown in colour (Photograph 1.10.). *Robinia pseudoacacia L.*, which has thick branches, has a lateral root system (Keskin, 2007).

Photograph 1.10. *Robinia pseudoacacia* stem form

The growth of the root in the soil is generally horizontal, but vertical roots can be seen in the development of some roots. The growth environment is quite wide. If high yield is to be achieved, they need soils with adequate levels of nutrients, adequate water capacity (groundwater 150 cm) and with a good aeration capacity. Clay soils should not be preferred because they prevent the soil from aeration. The best type of soil for this species is the ones that are thin sandy and lightly slimmy. It has the ability to tolerate drought and marginal soil structure. Besides dry and heavy soils, it can grow on very different soil types. However, in these conditions this plant should be preferred only in areas used for soil conservation and green cover. The average amount of rainfall in the geographical spreading areas is around 1000-1500 mm and 500-750 mm of this amount falls during the growing season. Checking the temperature demands, the average temperature of the summer months is 20-27 degrees and the maximum temperature is between 30-38 degrees. The winter averages are 2-8 degrees and the minimum is betwwen (-10)- (-25) degrees (Keskin, 2007).

It can grow fast and strongly under appropriate conditions. Increase in height in younger individuals is 1 meter per year, and the average height increase is 2 meters between 2-5 years. It maintains its rapid growth until the age of 20. After this age, height growth starts to decrease and after 40 years height growth does not occur. Volume development is rapid up to 30-40 years and then starts to slow down. Flowering starts in the 4th and 5th years. The individuals with well developed canopy and about 25-30 years old shows the best flowering capabilities. It can resist to frost up to some degrees (Keskin, 2007).

Through its nodules in its roots, it enriches the soil in terms of nitrogen content, by converting the free nitrogen in the air into soluble by water via nitrogen binding bacterias. This also helps the plants around them to develop. It is generally used to prevent soil loss and to plantation of loose-structured soils (Keskin, 2007).

Young shoots are green-red, brown, exposed and slightly villus and cornered. There are stinging thorns on the shoots. Leaflet numbers generally range from 7 to 19. The shape of leaves may be elliptical or egg-shaped. The upper surfaces of the leaves are light green and their lower surfaces are gray-green in colour. The leaves are singular and they are not covered with villus (Photograph 1.11).. Flowers that are fragrant are mostly white. Clusters of 10-20 cm in length are hanging down from the leaf ends. Fruits that are dark brown vary 5-10 cm in length and 4-10 in number in the form of broad beans. Acacia that likes light, best develops in river sides and in landfills. It can be grown easily anywhere in our country (Photograph 1.12.) (Yazılan, 2010). The current status of the Acacia planted areas is determined as 128.4 ha according to the data of General Directorate of Forestry (Keskin, 2007).

Photograph 1.11. *Robinia pseudoacacia* flower and leaf form

Photograph 1.12. *Robinia pseudoacacia* seed form

1.1.7. *Sophora japonica*

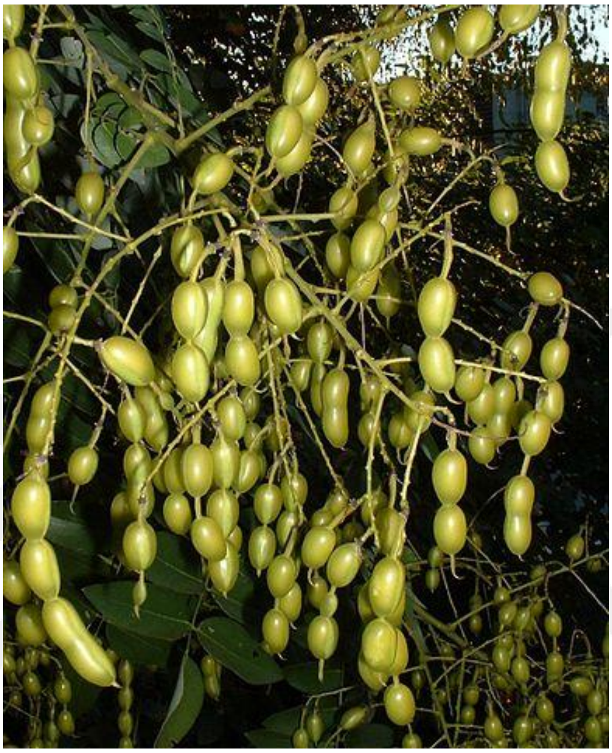
The geographical spread of *Sophora japonica* (Japanese pagoda tree, sofora) is Japan and China (Kaya, 2014). As a result of various investigations, it has not been determined whether the Turkish name of this plant taxon exists or not. Because the used English name is the Japanese Temple Plant, it was named as "temple plant" in

Turkish in the context of the Turkish Scientific Nomenclature Directive (Uygur and Erkul, 2015).

Sophora japonica can easily develop in countries with temperate climate regions. It is a species with the ability to make 20-25 meters length on average. This round-shaped plant species has a wide canopy and thick leaves and it can grow well in shade areas. The preferred types of soil are deep soils with good drainage. It shows good resistance to arid areas and polluted air of cities, but it can also get damaged by frost (Kaya, 2014). The leaves are in size of 15-20 cm and they have villus on them. Young shoots are green with no villus. The number of short-stemmed leaflets is between 7 and 17. The upper surfaces of the villus leaflets are bright dark green while the lower surfaces are bluish green in colour. The leaves gold coloured before they start to fall. The flowers in a standing cluster are yellowish white, fragrant and small flowers (Photograph 1.13.) (Kuş, 2013).

Photograph 1.13. *Sophora japonica* flower form

The seeds are 8-10 cm long and are in a floopy state. Once the leaves of the plant falls, the seeds form a beautiful appearance on the tree. The seeds, which are knotty, like knotted in fleshy broad beans, are black. The seeds have very hard testa and maturates in November- December. The seed collection time starts in November and continues until February (Photograph 1.14.). The flowers that bloom in the summer months can also stay on the tree for a long time. Because they have a decorative appearance, they are used as a solitary or alley tree in designs of parks and gardens to create a pleasant image. Due to its resistance to urban climate and smoky weather, they are frequently prefered in plantation of railway stations and around factories. The Pendula form produced by grafting is a very precious form (Kaya, 2014).



Photograph 1.14. *Sophora japonica* seed form

1.1.8. *Aesculus hippocastanum*

Aesculum hippocastanum is a plant species that is known with its magnificent image all over the world. Scientific name *Aesculus* is derived from the word "*esca*" which means food in Latin. The general name for the tree is the horse's chest because it looks like the eyes of the horses. It is also mentioned that these trees are used for the fracture treatment of hourses. The Latin name is *Aesculum hippocastanum L. (Hippocastanaceae)*. Other taxonomic names used in the literature are: *Aesculus castaneo Gilip., A. Procera Salisb., Castenea equino, Hippocastanum vulgare Gaertner*’dir (Akbel, 2010).

The georaphical spreading area of this species is Asia and India. It keeps to spread naturally in the Greece mountains, Bulgaria, northern Iran and the Himalayas (Özcimder, 2014). The recognition of this plant by Europe has occured after this species went to France from Istanbul (Konuk, 2012). The cultivated forms of horse chesnut have been produced to use in various fields in countries such as northern Europe, Britain, Denmark, Scandinavia, Turkey and Russia (Özcimder, 2014).

It has 2 genus and 13 species. A. *Paviave* and *A. Hippocastanum* are species in Turkey. They are grown as ornamental plants in parks and gardens in Turkey and in Europe.

Horse chesnut (*Aesculus hippocastanum*); has a capability of heighting up to 20-30 meters. The trunk of the tree is flat and columnar, and the canopy is broad and flat, as the branches are thick. The branches of this tree have a very rapid growing feature, showing a horizontal growth (Photograph 1.15.) (Konuk, 2012).

Photograph 1.15. Aesculus hippocastanum tree form (URL-3, 2018)

The form of radial leaves have a palmate shape with 5-9 leaflets. They are long-stalked and have a villus structure on the leaves. Their alignment may be opposing, leaf edges may be dentate or flat (Konuk, 2012). Dark green leaves get a yellowish brown color before they start to fall in the autumn. The leaves, which are in the form of a hand, have 7 lobes, about 20 cm in length and lined on petiole. The petioles are 10-15 mm in length, three in the upper side and two in the lower part, with a speckled structure rotating from yellow to pinkish red (Akyüz, 2010).

The flowers are in the form of a white, pyramid-shaped cluster with pink speckles on them. Matt red and rare yellow- colored flowering species are seen in South America. With the arrival of spring, the tree gets completely covered with flowers and spreads a pleasant image around it (Konuk, 2012). The tree starts to bloom down from the end point and the male flowers bloom first (Özcimder, 2014).

The outer surface of the fruit, which has thick membrane in the shape of capsules that grow in these flowers, is thorny. As the fruit matures, the green-colored thorny bark begins to split and 1-3 pieces of bright brown, harsh and bitter tasting seeds fall (Konuk, 2012). It is one of the most preferred species due to the location of the flowers on the tree in designs with decorative aims. It is also used in parks, road refuges and as shading trees. In the summer months they are pleasant looking because of the presence of flowers on them, with the fall of leaves thorny fruits emerge in autumn. It is resistant to cold weather conditions but it gets damaged by extreme frost. It shows good development in warm and sunny climate areas. He loves bright areas and half-shadow areas (Guest, 2012). It is resistant to cold weather conditions but the extremity is damaged by frost. It shows good development in warm and sunny climate areas. It likes light and semi-shade areas (Konuk, 2012).

Horse chestnuts fruits (seeds) contain; sugars, starch, fixed oils, flavonoids and glycosides (aesculin, esculin) and triterpenoid saponins (aescin, escin). There are 1-3 seeds in the capsule-shaped fruits. Fruits covered with thorns matures on August and October. The seeds are bright brown in color and 1-4 cm in diameter. The fruit capsule, which is in green color, has a three-chambered soft tissue and thorny structure. The seed is dark brown colored in the capsules (Photograph 1.16.). Some parts of the plant such as seed, leaf and trunk shells are medically used for the treatment of various diseases. Production of horse chestnut can be done with seeds as well as root cuttings and grafting. Except for use in parks and gardens Turkey has not yet begun to use this species for industrial aims. It yet keeps being an ornamental plant and has no contribution to the national economy. Also, there are no industrial establishments in our country with regard to the isolation and production of aescin (Özcimder, 2014).

Photograph 1.16. *Aesculus hippocastanum* seed form

1.2. The Signıficance of Heavy Metals

The Earth's atmosphere is mainly composed of oxygen (O_2), nitrogen (N_2) and carbon dioxide (CO_2). However, the rapid economic development, urbanization and industrialization processes that have taken place in the last 3 or 4 decades have radically destroyed the quality of the atmosphere by spreading various pollutants. The most common organic and inorganic atmospheric pollutants include ozone (O_3), sulfur dioxide (SO_2), nitrogen oxides (NO_x), CO_2, hydrogen fluoride, carbon monoxide (CO) and formaldehyde (HCHO) (Su and Liang, 2013; Su and Liang 2015; Cruz et.al., 2015). Today, some toxic pollutants are also releasing to the atmosphere as results of various human activities (Su and Liang, 2015). Industrialization is characterized by the release of significant amounts of heavy metals into the atmosphere and is a serious threat to human health and terrestrial ecosystems, mainly in mines and industrial areas (Shahid et al., 2017, Harguinteguy et al., 2016).

Although micronutrients such as manganese (Mn), zinc (Zn), chromium (Cr), copper (Cu), iron (Fe) and nickel (Ni) are required for living organisms including plants, they may cause harmful effects at high levels. Other metals such as Non-essential mercury (Hg), cadmium (Cd), arsenic (As) and lead (Pb) present serious toxicity to living organisms even at low application levels (Shahid, 2017; Shadid et. Al., 2015; Niazi et al., 2011; Harguinteguy et al., 2016).

Contamination of the atmosphere by heavy metals is mainly due to stationary or mobile sources such as waste incineration, petroleum combustion in homes for heating, power generation plants, industrial units, vehicle traffic and re-pollination of contaminated areas. Among them, heavy metal emissions from industrial and traffic activities are the most important source of atmospheric pollution (Uzu et al., 2011; Martley et al., 2004). Therefore, it is known that the concentration of heavy metals in the air is very high especially near industrial facilities and areas where the traffic is heavy (Shahid et al.,2017, Turkyilmaz et al., 2018; Shahid et al., 2013; Xiong et al., 2014; Schreck et al., 2013)

The concentration of heavy metals in the air also effects the plants. Heavy metals in the air can accumulate in organelles of plants such as root, crust, leaf, and fruit. This means that plants are effective absorptive structures; equipped with mechanisms for trapping heavy metals in the air. Indeed, metals can accumulate in plant leaves after the atmospheric particles have precipitated on leaf surfaces via leaf transfer (Xiong et al., 2014; Schreck et al., 2012). Biological monitoring studies near industrial sites or roads are therefore of more interest now to assess metal contamination by atmospheric deposition / transfer (Shahid et al., 2017)

Numerous studies have been carried out on the metal transfer of plants in roots (Pourrut et al., 2013; Schreck et al., 2013). However there are far less studies on the investigation of plant leaves metal uptakes (Shahid et al., 2017). Also many studies on metal uptake are not new and generally involve metal concentrations igronig the metal transferring pathways of the plants' leaves (Hutchinson and Whitby, 1974; Little, 1995; Løbersli and Steinnes, 1988; Salim et.al., 1993; Ward, 1990)

The intake of heavy metals by the leaves has been mainly evaluated for metals known to play important roles in the metabolic and biochemical reactions of plants. For example, some previous studies have focused on the absorption of Fe, Cu, Mn and Zn by the leaves (Wojcik, 2004; Fageria et al., 2009; Fernandez and Brown, 2013). It has been determined that these metals can penetrate cuticles and eventually accumulate in the underlying tissues of plant leaves (Vu et al., 2013). This has drawn attention to the relationship between the amount of metal accumulation in the plants and the amount of particulate matter in the air. As a matter of fact, it has been determined that the heavy metal accumulates on the particulate matter, the heavy metals penetrate into the leaf after the particulate matter is deposited on the leaf surface, and therefore there is a significant relationship between the amount of particulate matter and heavy metal accumulation in plants in industrial areas and areas where traffic is heavy (Egani et al., 2016, Norouzi et al., 2016, Shahid et al., 2017).

It has been reported that heavy metals coexist with mostly atmospheric particles due to their integration into the matrix structure during the burning process, or due to their adhesion to the surface of ferri-magnetics in the atmosphere. Particulate matter contains a complex mixture of various particles in the atmosphere, many of which are harmful (Shahid et al., 2017; Uzu et al., 2011). Therefore, in recent years, the amount of particulate matter has frequently been studied for the purpose of determining air quality in areas where the population is dense (Cetin et al., 2017).

Studies have shown that metals such as lead (Pb), cadmium (Cd), chromium (Cr) and arsenic (As) can penetrate plant leaves through leaf transfer (Schreck et al., 2013; Tudoreanu and Phillips, 2004; Levi et al., 1973; Leveque et al., 2014; Xiong et al., 2014; Shahid et al., 2017). Although significant progress has been made in recent years on the absorption of heavy metals from leaves in plants, there is still a lack of knowledge and this issue maintains its currency (Shahid et al., 2017)

Heavy metals are spread from various anthropogenic sources to atmospheres. In metal processing firms, the heating of mines is accompanied by air pollutants in a large amount and various heavy metals are spreading to the atmosphere (Chen et al., 2016). Besides that some particles (solid or liquid) suspended in the air, also called particulate matter (PM) or aerosol, pose a serious environmental threat. Heavy metals can spread in the atmosphere as volatile compounds and “volatile" emissions from industrial processes or as very thin particules via chimneys (Chen et al., 1986, Csavina et al., 2011; Csavina et al., 2012; Csavina et al., 2014). In addition, exhaust gases from vehicles also significantly affect air pollution in terms of heavy metals (Turkyilmaz et al., 2018).

Among air pollutants, especially heavy metals have great importance. Because, heavy metals can stay in nature for a long time without deterioration and concentration of heavy metals in the environment is constantly increasing. They also tend to bioaccumulate. Therefore, determination of the heavy metal concentration has great importance in determining the risk areas and risk level (El Hassan, 2000). Heavy metals released from industrial sources such as As, Cr, Pb, Ni, Zn, Cd and V are carcinogenic. Particularly in terms of potential toxicities and exposure to living organisms, As, Cd, Pb, Cr and mercury (Hg) are among the most toxic heavy metals. (Shahid et al., 2017).

Therefore, determination of the heavy metal concentration is crucial in determining the risk areas and the level of risk. However, there are two major problems with direct determination of atmospheric pollution. The first one of this major problems is that it is expensive, and the other one is that direct effect of atmospheric pollution on the ecosystem can not be determined (Alahababadi et al., 2017; Turkyilmaz et al., 2018; Cetin et al., 2017; Sevik et al., 2015).

The plants give important information about the concentration of these metals in the air by accumulating them in various organelles. Therefore, during the determination of air pollution indirectly, the trees show us the progress of the increase of heavy metal concentration in air over time, by accumulating heavy metals caused by fossil fuels especially in areas of heavy traffic, in their roots, fruites, crusts and leaves for many years. The plants are the best bioindicators that show us the heavy metal pollution in the air (Shahid et al., 2017; Janta et al., 2017)

Heavy metals spreading from industrial areas can be transported a few kilometers away from their source in the form of wet or dry sedimentation (Shahid et al., 2013; Douay et al., 2009). The presence of heavy metals in the air creates many health risks in the target organisms. The World Health Organization (WHO) has established guidelines for the risk of heavy metals exposure to the environment (WHO, 2007).

The nutrient, water and metal absorption potential of plant leaves have been documented about three hundred years ago (Fernandez and Eichert, 2009). Plants serve as an effective filter for heavy metal emissions in the atmosphere (Liu et al., 2012). Studies have shown that plants can effectively trap particulate matter in the leaves and reduce the proportion of particulate matter in the atmosphere (Al-Khashman et al., 2011; Turan et al., 2011). For example, it has been determined that a pine forest can hold about 36.4 t ha^{-1} of air dust per year (Feng, 1992). In Zhengzhou city of China, an area of 103 km^2 of plant cover has been determined to hold about 8,600 t yr^{-1} of dust particles (Zhou et al., 2001).

Studies have shown that high levels of heavy metals are found in the leaves of plants grown in industrial areas and in areas where traffic is heavy (Shahid et al., 2013; Uhlig and Junttila, 2001). Consequently, heavy metal levels in the leaves of plants are subjected frequently to the researches about environmental risk assessment (Schreck et al., 2012; Dumat et al., 2016). Studies have reported that industrial concentrations of heavy metal in cultivated vegetable tissues are several times higher than threshold levels (Douay et al., 2008; Stafilou et al., 2010). It was also determined that there is a strong relationship between the amount of heavy metal including particulate matter in the air and the heavy metal content of plants (Shahid et al., 2017).

The intake of heavy metals through leaf surfaces is through stomata, cuticular cracks, cavities, ectododes and aqueous pores (Fernandez and Brown, 2013; Fernandez et al., 2013). The absorption of heavy metals precipitated in the leaf is mainly through the helper cells protective cells on the cutaneous membrane or through the ectodomata, which are Non-plasmatic channels between and the epidermal cell wall. The cuticle on the protective cell is even more permeable compared to epidermal cells. Uzu et al. (2010) states that particulate matter adhering to plant leaves is mainly retained by villus and cuticle wax, but that some of the particulate-based metals may enter the leaf tissues of the plant. The cuticular properties in the upper part are very important in helping to absorb heavy metal by the upper surfaces. Kozlov et al., (2000) investigated the transfer of Cu and Ni-rich particles in birch wood, and found that particles could penetrate into plant leaves through stomata. Fernandez and Eichert (2009) also state that particles can enter leaf tissue through leaf cuticles and through pores in stomata. As in the case of root ingestion, intake of heavy metals by the leaf may also occur in a dose dependent manner. For example, Kozlov et al. (2000) reported that there is a linear relationship between the Ni contents in the leaf and the Ni content in the medium and heavily contaminated areas in the Kola peninsula in Russia. Similarly, it was reported that there is a linear relationship between As level applied from the leaf and As intake of the fern (Bondada et al., 2004). Therefore, it is stated that plants are a good bioindicator in determining the concentration of heavy metals in the air and plants are used intensively for this purpose.

1.3. Studies on the Use of Plants As Biomonitors on Heavy Metal Accumulation

Various plants can be used as bioindicators of atmospheric heavy metal pollution. Among these plants, a large number of studies have been done especially on lichens and algae (Garty, 2001, Bergagli and Nimis, 2002, Szczepaniak and Biziuk, 2003, Bergagli and Nimis, 2002). The diversity of epiphytic lichens is an appropriate and powerful indicator of air quality (Loppi et al., 2002). Macrolics, which are lichens in the leafy life form, and look like bushes are used more often to monitor the air quality. Rather than drawing simple maps of pollutant levels in the atmosphere, researchers have found that there is a relationship between lichen bioindicators and locally increased levels of serious diseases such as cancer (Cislaghi and Nimis, 1997). Various methods such as abundance of the species, health and diversity, isotopic and chemical composition evaluation can be applied to monitor lichens biologically. Transplant lichens can be used where lichens are not found naturally (Shahid et al., 2017).

The physiology of the lichens facilitates the absorption of atmospheric pollutants from air through all surfaces, thus reducing the atmospheric pollutants that are formed by dry precipitation, wet precipitation and gaseous diffusion (Fenn et al., 2007; Conti and Cecchetti, 2001). This characteristic of lichens is related to their ability to accumulate airborne particles. In contrast to flowering plants, lichens have a protective wax layer on the outside and a special organ for water absorption, so they passively absorb the phases and particulate matter (Bates, 2002). The heavy metal concentrations in the lichens are parallel to the levels in the atmosphere (Sloof, 1995; Bari et al., 2001). The capacity of accumulating high amounts of trace elements of lichens and their susceptibility to them depends on their species and are determined by their structural and morphological characteristics (Carreras et al., 2005).

Algae are also frequently used as bioindicators of heavy metal pollutants such as lichens (Harmens et al., 2004; Fernandez et al., 2000; Harmens et al., 2010). The use of bryophytes as bioindicators of the accumulation of atmospheric metal pollution began in the late 1960s in Europe. Because of their widespread availability, their lower cost and the higher absorption capacities of pollutants, bryophytes are used more widely than other absorbent materials (Giordano et al., 2013; Ares et al., 2012).

Algae usually accumulate water from the rain, making them useful for assessment of biological exposure to atmospheric deposition. However, some studies have shown that some algae may take up mineral elements from the soil (Ayres et al., 2006; Klos et al., 2012). Nevertheless, it seems that the intake of nutrients from the soil is small when compared with the intake from the atmosphere. The fact that the biomass of the algae is abundant, is found in various ecosystems and everywhere in the world makes them a suitable bioindicator. Algae have heavy metal accumulation capacity in high quantities which lead to higher element concentrations compared to water or air (Shahid et al., 2017).

In recent years, especially high-structured plants have been used frequently in determining the heavy metal concentration. The main reason for this is the variety of plants especially used in landscape studies. Heavy metals can accumulate on the root, stem, leaf, fruit and so etc. of the plants. Therefore, a number of studies have been carried out on the use of plants as biomonitors in determining heavy metal pollution.

Aksoy and Şahin (1999) stated in their paper named "The use of *Elaeagnus angustifolia L.* as a bioindicator in heavy metal contamination" that *Elaeagnus angustifolia L. (Elaeagnaceae)* have investigated the possibility of using leaves of this plant as biomonitor. Within the study, *Elaeagnus angustifolia L.* leaves were collected in Kayseri and some of them were washed. The concentration of Pb, Cd and Zn in soil samples and washed and unwashed plant samples were determined by heavy metal analysis. In the results of study; *E. angustifolia* has been identified as a good biological monitor.

Serbula et al. (2012) determined the amount of Cu, Zn, Pb, Cd, As and Hg in branches, leaves and roots of *Robinia pseudoacacia L* in their study. As a result of the study, they stated that *Robinia pseudoacacia L.* is not a good biomonitor in the detection of environmental pollution.

Çelik et al. (2005) determined the amounts of Fe, Zn, Pb, Cu, Mn and Cd in washed and unwashed leaves in *Robinia pseudoacacia L*. in their study which was conducted in Denizli. In the study, leaves collected from industrial areas, roadsides, suburbs and rural areas were used. As a result of the study, they stated that *Robinia pseudoacacia L.* is a good biomonitor in the determination of heavy metal accumulation caused by traffic and in industrial areas.

Çavuşoğlu and Çavuşoğlu (2005) investigated Pb pollution caused by vehicles on the leaves of *Cupressus sempervirens* and *Cedrus libani* trees, which are lined along the 10km road between Isparta City Center Entrance and Süleyman Demirel University, and consequently they found out that Pb pollution in both plants increased as approaching to city. As a result of the study, it was also found that the leaf of

Cupressus semipervirens plant contains more lead (Pb) than *Cedrus libani* due to its anatomical structure.

Demirayak et al. (2011) determined heavy metal accumulation in some natural and exotic plants in Samsun province. Within the scope of the study, they determined the amounts of Pb, Cd, Zn and Cu in leaf samples collected from the city center and from Atakum district which is a suburb district. The most amount of heavy metal concentrations were found in the *Magnolia grandiflora*, although heavy metal concentrations may vary depending on the species studied, localities and sampling time. According to the obtained data, *M. grandiflora, L. vulgare* and *P. dactylifera* could be used as biomonitors.

Li et al. (2007) determined the quantities of Zn, Cd, As, Hg, Pb, Cr, Ni and Co in soil and leaves of *Sophora japonica* in their study that was aimed to determine heavy metal accumulation due to traffic.

Suzuki et al. (2009) investigated the possibility of using *Rhododendron pulchrum* leaves as bioindicators of traffic pollution in Okayama, Japan. As a result of the correlation analysis that was conducted within their study, they determined that there is a strong correlation between Pb, Ni and Zn. As a result of the study, they also stated that *Rhododendron pulchrum* could be used as a bioindicator in the determination of heavy metal pollution in areas where traffic is heavy.

Tanushree et al. (2011) studied the concentrations of Cu, Ni, Pb and Zn in the leaves of *Alstonia scholaris, Ficus bengalensis, Morus alba*, and *Polyalthia longifolia* in their study in Anand, India. At the end of the study, the highest values were obtained in *Morus alba.*

Sawidis et al. (2011) conducted heavy metal analyzes on samples collected from contaminated and Non-contaminated sites in Salzburg, Belgrade and Thessaloniki. In the study, leaf and bark samples were collected from *Platanus orientalis L.* and *Pinus nigra* individuals and heavy metal analysis was carried out. As a result of the study, it was determined that it is appropriate to use both of these species as bioindicators in determination of heavy metal pollution.

Gratani et al. (2008) determined concentrations of Al, Fe, Cu, Zn, and Pb in *Quercus ilex* leaves in Rome. The study concluded that *Quercus ilex* is a suitable species for the use as biomonitor in heavy metal pollution and that heavy metal pollution is associated with motor vehicles.

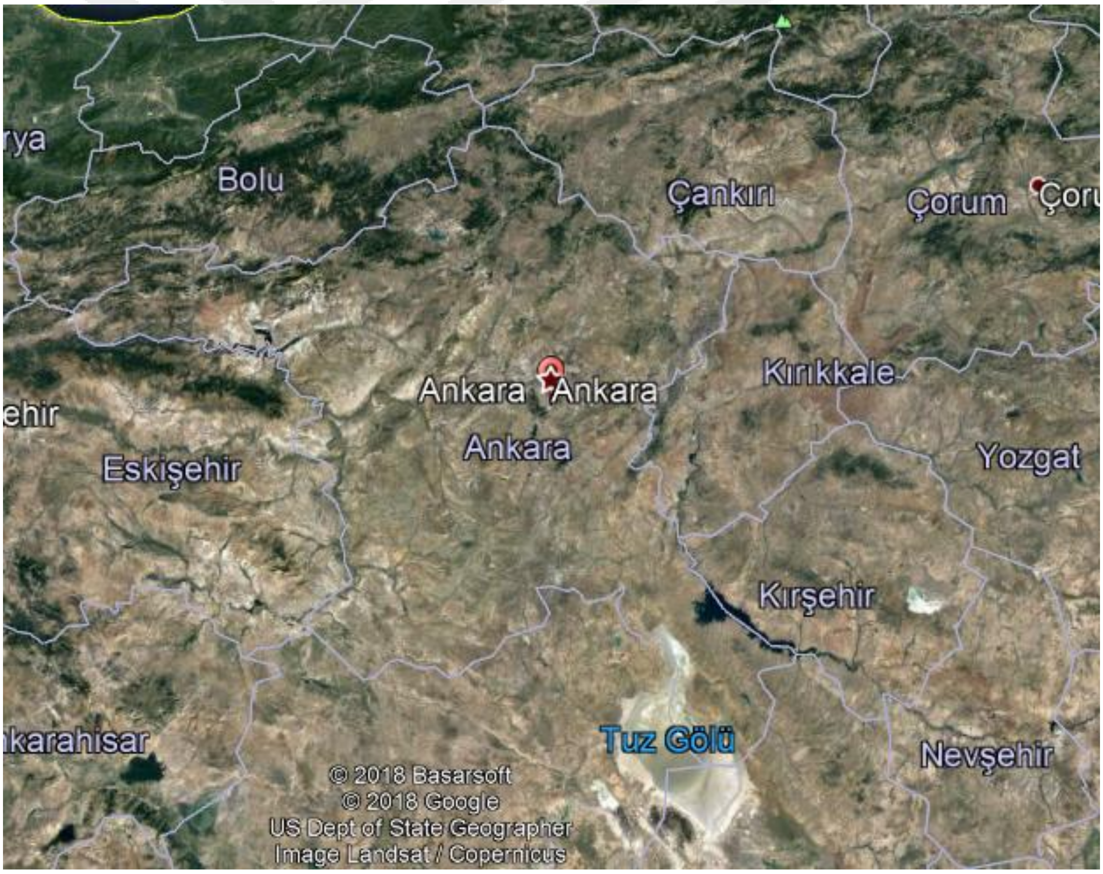
Li et al., (2007) determined that Zn, Cd, Hg, Pb and Cr accumulate considerably in both soil and leaves of *Sophora japonica L.* on the road sides in Northeast China in their study of heavy metal pollution of leaves.

There are many more studies conducted on the use of plants in determining the heavy metal concentration. However, here are just some examples of the studies conducted.

2. MATERIAL AND METHOD

2.1. Collection of the Samples and the Tree Species

Materials collected from Ankara city center were used in the study. Ankara is the capital of Turkey and the calculated the population of the city was 5.346.518 in year 2016 (URL-4, 2016) and is one of Turkey's largest cities. The samples were collected from the Ulus-Kızılay region, which is the city center (Photograph 2.1). In the scope of the study, the area where the samples were collected is Kızılay- Ulus route, which is a region with high traffic density with an 8-lane highway with 4 lanes each side (Photograph).



Photograph 2.1. Ankara map

Photograph 2.2. Ankara -Kızılay

In the scope of the study, areas where traffic is heavy are accepted as areas on the highway route. Areas where traffic is less intense are the back streets of the highway, where there is a two-lane road. In areas where traffic is low, traffic is getting heavy during rush hours (Photograph 2.3).

Photograph 2.3. Ankara –Kızılay back street

The areas defined as Non-traffic areas are selected from the places of which has no Access for any vehicles at least at 50 meters distance. These areas are the inner parts of the urban parks in Ulus-Kızılay region (Figure). The Non-traffic areas where samples are collected from have been marked on the map on Figure and the photographs of the area are given in Photograph 2.4.

Photograph 2.4. Ankara –Kızılay Güvenpark

Within the scope of the study, approximately 1 kg leaf samples were collected from *Salix babylonica, Tilia tomentosa, Eleagnus angustifolia, Robinia pseudoacacia, Sophora japonica, Prunus cerasifera, Ailanthus altissima and Aesculus hippocastanum* species that are used frequently in landscape studies. Leaf samples were collected at the end of the 2016 vegetation period and brought to the laboratory after being bagged and labeled.

2.2. Analytical Method

The samples, which were classified and labeled in the laboratory, were kept for 15 days until they became air-dried. A general view of the samples waiting to be air-dried in the laboratory is given in the Photograph 2.5.

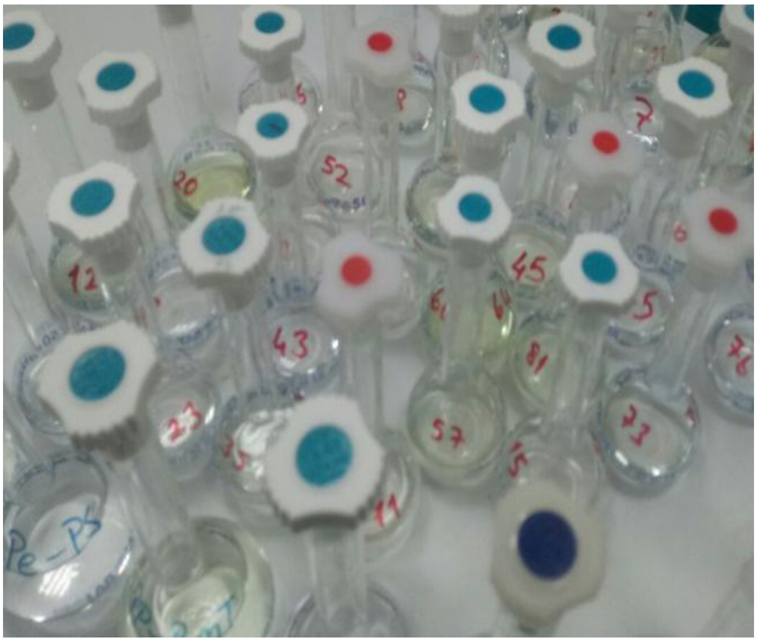
Photograph 2.5. Dried samples at laboratory

Leaves that became air-dried were taken into glass containers and dried at 50 ° C for one week in drying stove (Photograph 2.6). Experiments were started for heavy metal analysis in dried samples on the same day.

Photograph 2.6. Dried samples at etuv

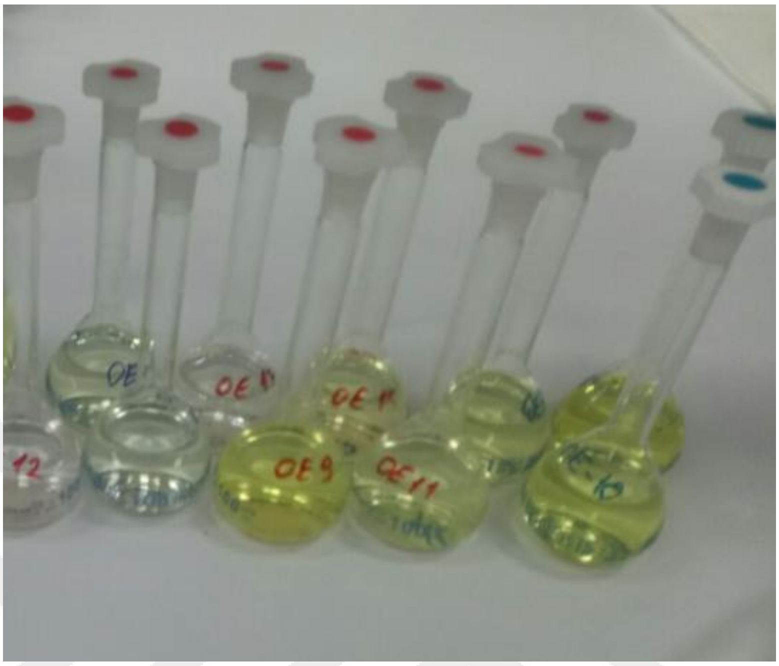
2.3. Definition of the Heavy Metals

2 g of the dried samples were weighed and placed in 10 ml of concentrated HNO_3 at room temperature for 1 day. It was then boiled at 180 ° C for 1 hour. Worked on the fume cupboard during the process of adding HNO_3 boiling at 180 ° C (Photograph 2.7.).



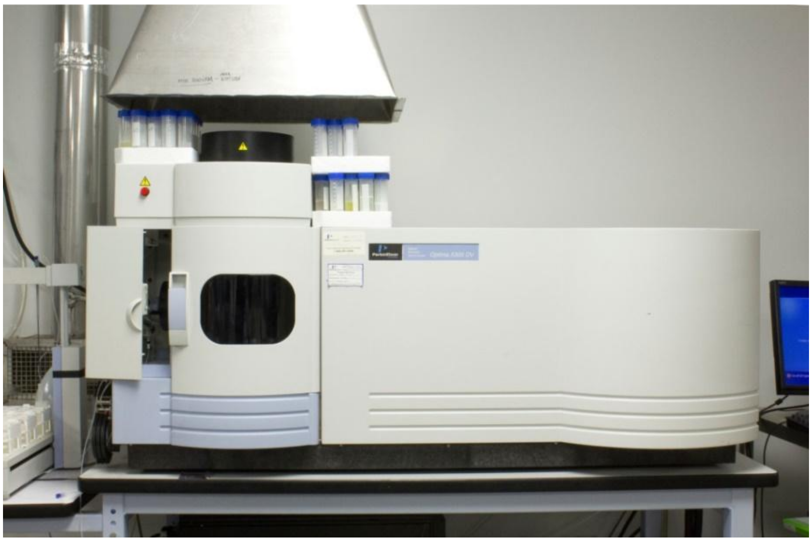
Photograph 2.7. Examples of working in the Çeker Ocak

Then 20 ml of distilled water was added to the solution and the solution was filtered through 45 μm filter paper (Photograph 2.8.).



Photograph 2.8. Solutions obtained from the filtrate

In the solutions obtained from the filtrate; heavy metal analyzes were performed with GBC Integra XL-SDS-270 ICP-OES device to determine the amounts of Pb, Cu, Ca, Mg, Cd, Cr, Ni, Fe, In the study, and the image of the ICP-OES device that was used to perform the heavy metal analyzes is given in the Photograph 2.9.



Fotoğraf 2.9. Device with heavy metal analysis

2.4. Statistical Analysis

The obtained data were evaluated with the help of SPSS package program, variance analysis was applied to the data and homogeneous groups were obtained by applying the Duncan test to the values having at least 95% confidence level differences statistically. The obtained data is simplified and tabled and interpreted.

3. FINDINGS

The data obtained in the study were evaluated with SPSS package program and it was tried to determine whether there is any difference in species among the species in terms of elements. The results of variance analysis applied to the data are given in the Table 3.1.

Table.3.1. *Results of variance analysis on species basis*

		Sum of Squares	df	Mean Square	F	Sig.
Pb	Between Groups	1015,140	7	145,020	10,997	,000
	Within Groups	843,967	64	13,187		
	Total	1859,107	71			
Cu	Between Groups	174317,861	7	24902,552	11,145	,000
	Within Groups	143004,923	64	2234,452		
	Total	317322,784	71			
Ca	Between Groups	30,982	7	4,426	5,785	,000
	Within Groups	48,967	64	,765		
	Total	79,948	71			
Mg	Between Groups	1,046	7	,149	4,709	,000
	Within Groups	2,030	64	,032		
	Total	3,076	71			
Cd	Between Groups	49679,083	7	7097,012	28,900	,000
	Within Groups	15716,772	64	245,575		
	Total	65395,854	71			
Cr	Between Groups	3759,135	7	537,019	7,962	,000
	Within Groups	4316,652	64	67,448		
	Total	8075,787	71			

Table.3.1. Continue

Ni	Between Groups	827,027	7	118,147	6,766	,000
	Within Groups	1117,483	64	17,461		
	Total	1944,511	71			
Fe	Between Groups	4409,841	7	629,977	8,295	,000
	Within Groups	4860,324	64	75,943		
	Total	9270,165	71			
Mn	Between Groups	95,633	7	13,662	2,746	,015
	Within Groups	318,450	64	4,976		
	Total	414,083	71			
Zn	Between Groups	974,845	7	139,264	16,504	,000
	Within Groups	540,048	64	8,438		
	Total	1514,893	71			

When the table values are examined in terms of all the elements, it is observed that statistically significant differences exist between the species. These differences are significant at 95% confidence level for Mn and 99.9% for other elements. The Duncan test was applied to determine the grouping of the data on the basis of species, and the mean species-based values for Pb, Cu, Ca, Mg and Cd and the homogeneous groups resulting from the Duncan test are given in the Table 3.2.

Table 3.2. *The Duncan test results of Pb, Cu, Ca, Mg and Cd elements on the basis of species*

Türler	Pb(ppb)	Cu(ppb)	Ca(ppm)	Mg (ppm)	Cd (ppb)
Salix babylonica	8,093 a	49,364 a	**1,534 a**	0,423 ab	**84,935 b**
Tilia tomentosa	16,322 ab	**32,824 a**	2,234 ab	0,380 a	14,780 a
Eleagnus angustifolia	8,468 a	54,764 a	**1,532 a**	**0,314 a**	5,884 a
Robinia pseudoacacia	12,994 ab	36,957 a	2,858 bc	0,468 abc	5,160 a

Table 3.2. Continue

Sophora japonica	14,544 ab	155,222 b	**3,448 c**	**0,701 d**	4,737 a
Prunus cerasifera	**7,511 a**	**169,475 b**	2,901 bc	0,585 bcd	3,957 a
Ailanthus altissima	14,502 ab	77,806 a	2,892 bc	0,610 cd	**3,431 a**
Aesculus hippocastanum	**17,904 b**	72,515 a	2,057 ab	0,471 abc	5,200 a

When the Duncan test results on species are examined, it is seen that the data are collected in two homogenous groups in terms of Pb concentration. The lowest values were obtained in *Prunus cerasifera* (7,511 ppb) and *Salix babylonica* (8,093 ppb) while the highest values were obtained in *Tilia tomentosa* (16,322 ppb) and *Aesculus hippocastanum* (17,904 ppb).

The difference between the lowest value and the highest value is more than twice as much. In terms of Cu, the data are also collected in 2 homogeneous groups. The lowest value in terms of Cu concentration was obtained in *Tilia tomentosa* with 32,824 ppb and the highest value in *Prunus cerasifera* with 169,475 ppb. It is noteworthy that the value obtained in *Prunus cerasife*ra is about 5.16 times more than that obtained in *Tilia tomentosa*.

As a result of the Duncan test it was determined that the values were collected in three homogenous groups in terms of Ca concentration, the lowest values were of *Eleagnus angustifolia* (1,532 ppm) and *Salix babylonica* (1,534 ppm), which were only in the first homogeneous group; and the highest value was of *Sophora japonica* (3,448 ppm) which was only in the last homogeneous group. The value obtained from *Sophora japonica* is twice more than that from *Eleagnus angustifolia* and *Salix babylonica*. Similarly, there is twice more difference between *Eleagnus angustifolia* of which the lowest values are obtained in terms of Mg concentration and *Sophora japonica* of which the highest values are obtained.

In terms of Cd concentration, the data were collected in two homogenous groups, with the highest values of *Salix babylonica* (84,935 ppb) forming the second homogeneous group alone, while all other species were in the first homogeneous group. In the first homogeneous group, the Cd values range from 3,431 ppb to 14,780 ppb.

The Duncan test was applied to determine grouping of the data on the basis of the species, and the mean values of Cr, Ni, Fe, Mn and Zn on the basis of species with the homogeneous groups formed by the Duncan test are given in the Table 3.3.

Table 3.3. *Duncan test results for Cr, Ni, Fe, Mn and Zn on the basis of species*

Türler	Cr (ppb)	Ni (ppb)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Salix babylonica	24,151 ab	12,048 b	**8,495 a**	4,713 ab	**14,084 d**
Tilia tomentosa	27,668 b	4,571 a	15,151 ab	4,864 ab	5,113 bc
Eleagnus angustifolia	24,360 ab	4,746 a	10,813 ab	**7,315 c**	**6,037 c**
Robinia pseudoacacia	21,233 ab	8,015 a	15,206 ab	**4,084 a**	5,282 bc
Sophora japonica	**40,304 c**	5,473 a	**34,691 c**	5,557 abc	5,171 bc
Prunus cerasifera	**16,431 a**	**13,413 b**	16,446 ab	4,824 ab	2,386 ab
Ailanthus altissima	16,504 a	5,224 a	**9,368 a**	6,855 bc	2,482 ab
Aesculus hippocastanum	28,928 b	**4,151 a**	19,497 b	6,977 bc	**1,540 a**

When Duncan test results are examined, it is seen that the data are collected in three homogeneous groups in terms of Cr, the lowest values are obtained from *Prunus cerasifera* (16,431 ppb) and *Ailanthus altissima* (16,504 ppb) and the highest value is of *Sophora japonica* (40,304 ppb). In terms of Ni, the data were collected in two homogenous groups, *Salix babylonica* and *Prunus cerasifera* were in the second group while all other species were in the first homogeneous group.

The lowest values were obtained from *Salix babylonica* (8,495 ppm) and *Ailanthus altissima* (9,368 ppm) while the highest values were obtained from *Sophora japonica* (34,691 ppm) in terms of Fe concentration. There is about 3.5 times more difference between the lowest value and the highest value in terms of Fe.

The data were also collected in three homogenous groups in terms of Mn and Zn. The lowest value of Mn was obtained from *Robinia pseudoacacia* (4,084 ppm) and the highest value was obtained from *Eleagnus angustifolia* (7,315 ppm). The lowest value for Zn was obtained in *Aesculus hippocastanum* (1,540 ppm) and the highest values were of *Eleagnus angustifolia* (6,037 ppm) and *Salix babylonica* (14,084 ppm). It is noteworthy that the value obtained from *Salix babylonica* is nine times more than the value obtained from *Aesculus hippocastanum*.

Variance analysis was applied to the data to determine whether there were statistically significant differences in at least 95% confidence level between the element amounts depending on the traffic intensity and the results are given in the Table 3.4.

Table 3.4. *Variance analysis results in terms of traffic intensity*

		Sum of Squares	df	Mean Square	F	Sig.
Pb	Between Groups	534,185	2	267,092	13,910	,000
	Within Groups	1324,922	69	19,202		
	Total	1859,107	71			
Cu	Between Groups	55549,830	2	27774,915	7,321	,001
	Within Groups	261772,954	69	3793,811		
	Total	317322,784	71			
Ca	Between Groups	30,147	2	15,073	20,884	,000
	Within Groups	49,802	69	,722		
	Total	79,948	71			
Mg	Between Groups	,544	2	,272	7,412	,001
	Within Groups	2,532	69	,037		
	Total	3,076	71			
Cd	Between Groups	2969,703	2	1484,852	1,641	,201
	Within Groups	62426,151	69	904,727		
	Total	65395,854	71			

Table 3.4. Continue

Cr	Between Groups	1283,115	2	641,558	6,517	,003
	Within Groups	6792,672	69	98,445		
	Total	8075,787	71			
Ni	Between Groups	600,235	2	300,118	15,405	,000
	Within Groups	1344,275	69	19,482		
	Total	1944,511	71			
Fe	Between Groups	2363,817	2	1181,908	11,808	,000
	Within Groups	6906,348	69	100,092		
	Total	9270,165	71			
Mn	Between Groups	148,026	2	74,013	19,195	,000
	Within Groups	266,057	69	3,856		
	Total	414,083	71			
Zn	Between Groups	328,711	2	164,355	9,561	,000
	Within Groups	1186,182	69	17,191		
	Total	1514,893	71			

When the results in the table are examined, it is seen that all the elements except Cd element changed significantly at least 95% confidence level depending on traffic density. This change is significant at 99% confidence level for Cu, Mg and Cr and 99.9% for other elements. The Duncan test was applied to determine how the elements subjected to the study are grouped according to the traffic intensity and the mean values for Pb, Cu, Ca, Mg and Cd and the groupings according to the Duncan test results are given in the Table.

Table 3.5. *The Duncan test results in terms of Pb, Cu, Ca, Mg and Cd depending on the traffic intensity*

Traffic	Pb(ppb)	Cu(ppb)	Ca(ppm)	Mg (ppm)	Cd (ppb)
Non	9,157 a	52,983 a	1,703 a	,414 a	7,433 a
Low dense	12,644 b	71,440 a	2,317 b	,453 a	17,713 a
Heavy	15,826 c	118,925 b	3,276 c	,615 b	22,885 a

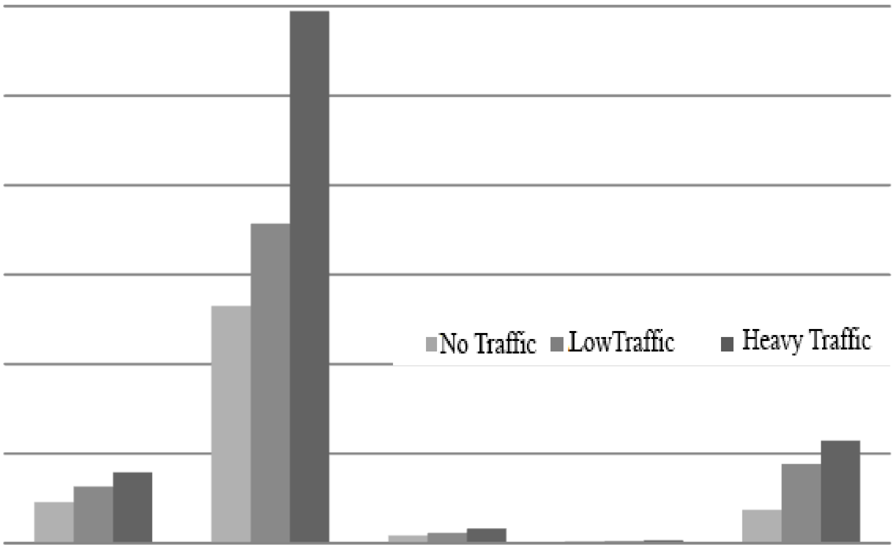


Figure 3.1. The Duncan test results in terms of Pb, Cu, Ca, Mg and Cd depending on the traffic intensity

When the table values are examined, it is seen that the traffic intensity is effective on the quantity of all the elements, and the amount of the elements increases together with the increasing traffic density. According to the results of Duncan test, it is seen that the data is composed of three homogeneous groups in terms of Pb and Ca, and two homogeneous groups in terms of Cu and Mg. For Cu and Ca elements, the areas with Non or low traffic intensity were in a group, while the areas where the traffic was intense were a separate group. The mean values for Cr, Ni, Fe, Mn and Zn and groupings results from the Duncan test are given in the Table 3.6.

Table 3.6. *The Duncan test results in terms of Cr, Ni, Fe, Mn and Zn depending on the traffic intensity*

Traffic	Cr (ppb)	Ni (ppb)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Non	18,980 a	4,270 a	8,879 a	4,367 a	2,603 a
Low dense	27,787 b	6,214 a	16,881 b	4,929 a	5,348 b
Heavy	28,075 b	11,131 b	22,865 c	7,650 b	7,835 c

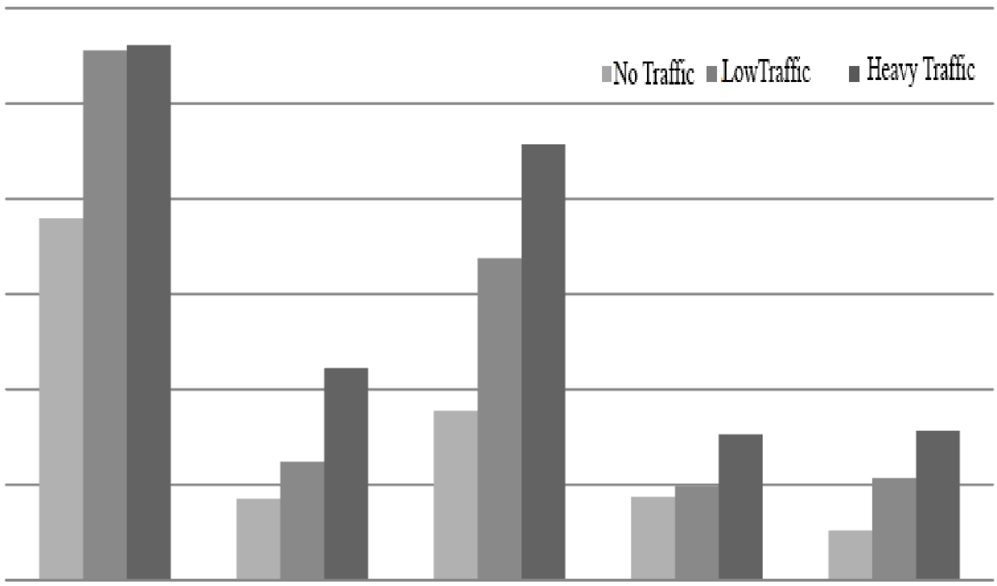


Figure 3.2. The Duncan test results in terms of Cr, Ni, Fe, Mn and Zn depending on the traffic intensity

According to the Duncan test results, three homogeneous groups were formed in terms of Fe and Zn and two homogeneous groups in terms of other elements as it is seen on the table. For Ni and Mn; while areas with Non and low density traffic were in a homogeneous group, and areas with high traffic density were in a seperate homogeneous group, for Cr; areas with Non traffic were in a homogeneous group, and areas with low and high density traffic were in other homogeneous group. When the average values are examined, it is seen that the traffic intensity is effective on the quantity of all the elements, and the quantity of the elements increases with the increasing traffic density.

3.1. Variation of Elements Depending on Traffic Density on the Basis of the Species

The main purpose of this study is to determine the variation of the amount of the elements depending on the traffic intensity on the basis of species. Within this scope; variation in the amount of the elements were determined by analyzing leaf samples taken from areas where there was no traffic, low dense or heavy traffic, and the variations of each element depending on plant species and traffic intensity were evaluated separately.

3.1.1. Variation of Pb Concentration Depending on Traffic Density on the Basis of the Species

Within the scope of this study, the variation of the Pb concentration depending on the plant species in areas with Non, low dense and heavy traffic was determined and the average values, the F value with significance level obtained from the analysis of variance, and the homogeneous groups formed by the Duncan test were given in the Table 3.7.

Table 3.7. Variation of pb concentration depending on traffic density on the basis of the species

	Non	Low dense	Heavy	**F Val**
Tilia tomentosa	10,920 a	17,106 b	20,940 b	**15,407****
Eleagnus angustifolia	8,073 a	8,133 a	9,200 a	**,267 ns**
Prunus cerasifera	3,733 a	5,733 b	13,066 c	**146,175*****
Ailanthus altissima	12,560 a	15,120 a	15,826 a	**2,465 ns**
Salix babylonica	5,006 a	8,953 b	10,320 b	**17,369****
Robinia pseudoacacia	8,856 a	13,753 b	16,373 b	**13,368****
Sophora japonica	9,526 a	14,813 ab	19,293 b	**9,760 ***
Aesculus hippocastanum	14,580 a	17,540 b	21,593 c	**10,281***

When the results of the table are examined, it is seen that Pb concentration does not differ at the significant levels statistically depending on traffic density for *Eleagnus angustifolia* and *Ailanthus altissima*, which are the subjected species of study, at least at 95% confidence level. In all other species, Pb concentration differed at least at 95% confidence level depending on traffic intensity, 95% for *Sophora japonica* and *Aesculus hippocastanum*, 99% for *Robinia pseudoacacia*, *Salix babylonica* and *Tilia tomentosa* and at 99.9% confidence level for *Prunus cerasifera*.

According to the table; in areas with Non traffic, the concentration of Pb varies between 3,733 ppb (*Prunus cerasifera*) and 14,580 ppb (*Aesculus hippocastanum*) while it is between 5,733 ppb (*Prunus cerasifera*) and 17,540 ppb (*Aesculus hippocastanum*) in areas with low dense traffic and in areas with heavy traffic it varies between 9,200 ppb (*Eleagnus angustifolia*) and 21,593 ppb (*Aesculus *hippocastanum*). The graph showing the variation of the Pb Concentration due to the traffic intensity on the basis of species is given in the Figure 3.3.

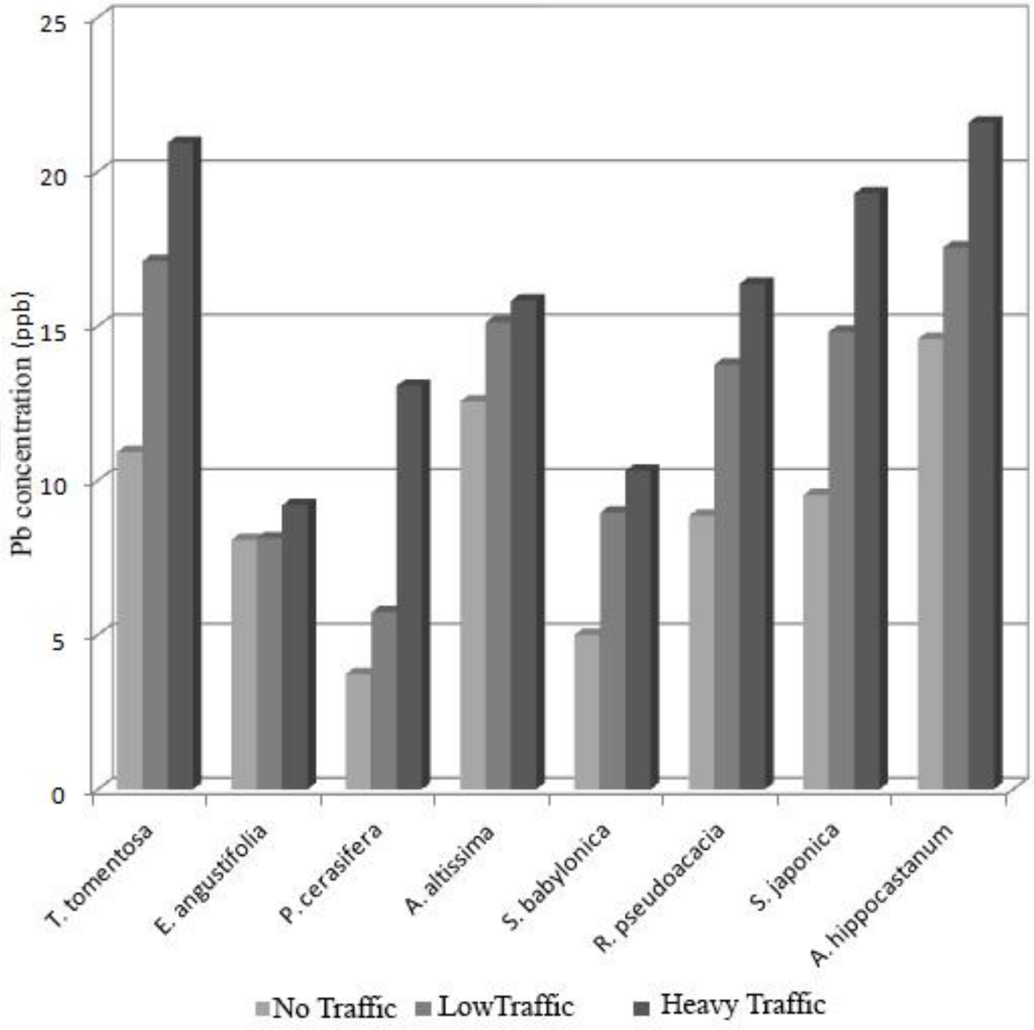


Figure 3.3. Variation of Pb Concentration Depending on Traffic Density on the Basis of the Species

When the differences between the areas where the traffic is heavy and the areas where there is no traffic are examined, it was seen that the Pb Concentration of the areas where traffic is heavy is 1,918 times morein *Tilia tomentosa*, 1,14 times morein *Eleagnus angustifolia*, 3.5 times more in *Prunus cerasifera*, 1,26 times morein *Ailanthus altissima*, 2,062 times more in *Salix babylonica*, 1,849 times more in *Robinia pseudoacacia*, 2,025 times more in *Sophora japonica* and 1,481 times more in *Aesculus hippocastanum* than the concentration of lead in the areas where there is no traffic. According to these values, it can be said that the most variation depending on the traffic intensity was seen in *Prunus cerasifera*, *Salix babylonica* and *Sophora japonica*. The least variation is observed in *Eleagnus angustifolia* and *Ailanthus altissima*.

3.1.2. Variation of Cu Concentration Depending on Traffic Density on the Basis of the Species

Within the scope of this study, the variation of the Cu concentration depending on the plant species in areas with Non, low dense and heavy traffic was determined and the average values, the F value with significance level obtained from the analysis of variance, and the homogeneous groups formed by the Duncan test were given in the Table.

Table 3.8. *Variation of Cu Concentration Depending on Traffic Density on the Basis of the Species*

	Non	Low dense	Heavy	**F Val**
Tilia tomentosa	28,726 a	29,046 a	40,700 b	**6,303***
Eleagnus angustifolia	48,280 a	50,186 a	65,826 b	**179,310*****
Prunus cerasifera	148,253 b	127,593 a	232,580 c	**600,178*****
Ailanthus altissima	53,200 a	77,560 b	102,660 c	**236,980*****
Salix babylonica	35,400 a	43,146 b	69,546 c	**104,923*****
Robinia pseudoacacia	22,533 a	31,353 b	56,986 c	**83,110*****
Sophora japonica	31,260 a	130,853 b	303,553 c	**759,125*****
Aesculus hippocastanum	56,213 a	81,786 b	79,546 b	**24,424****

According to the results of the variance analysis, it was determined that the Cu Concentration was statistically different at the level of at least 95% confidence level depending on the traffic intensity for all species subjected to this study. Differences determined on the basis of traffic intensity are significant at 95% confidence level for *Tilia tomentosa*, 99% for *Aesculus hippocastanum* and at 99.9% confidence level for other species.

According to the Duncan test results, the data obtained from *Tilia tomentosa, Eleagnus angustifolia* and *Aesculus hippocastanum* were collected in two homogenous groups, whereas from the data obtained from other species three homogenous groups were formed and each value was in a separate homogeneous group. While the areas with Non and low density traffic were in the same homogenous group for *Tilia tomentosa* and *Eleagnus angustifolia*; the areas with low and high density traffic were in the same group for *Aesculus hippocastanum.* While the Cu concentration was at 148,253 ppb of *Prunus cerasifera* in areas with Non traffic; it was at 127,593 ppb in areas with low density traffic. In all other species, the Cu concentration increased due to traffic intensity.

The highest Cu concentrations were found in *Prunus cerasifera* (148,253 ppb) in areas with Non traffic while the lowest values were obtained from *Robinia pseudoacacia* (22,533 ppb) and *Tilia tomentosa* (28,726 ppb). The highest Cu values were determined in *Sophora japonica* (130,853 ppb) and *Prunus cerasifera* (127,593 ppb) in areas with low dense traffic, while the lowest values were determined in *Robinia pseudoacacia* (31,353 ppb) and *Tilia tomentosa* (29,046 ppb). The highest Cu values were determined in *Sophora japonica* (303,553 ppb) and *Prunus cerasifera* (232,580 ppb), while the lowest values were determined in *Robinia pseudoacacia* (56,986 ppb) and *Tilia tomentosa* (40,700 ppb) again in the areas where the traffic is heavy. The graph showing the variation of the Cu concentration depending on the traffic intensity on the basis of species is given in Figure 3.4.

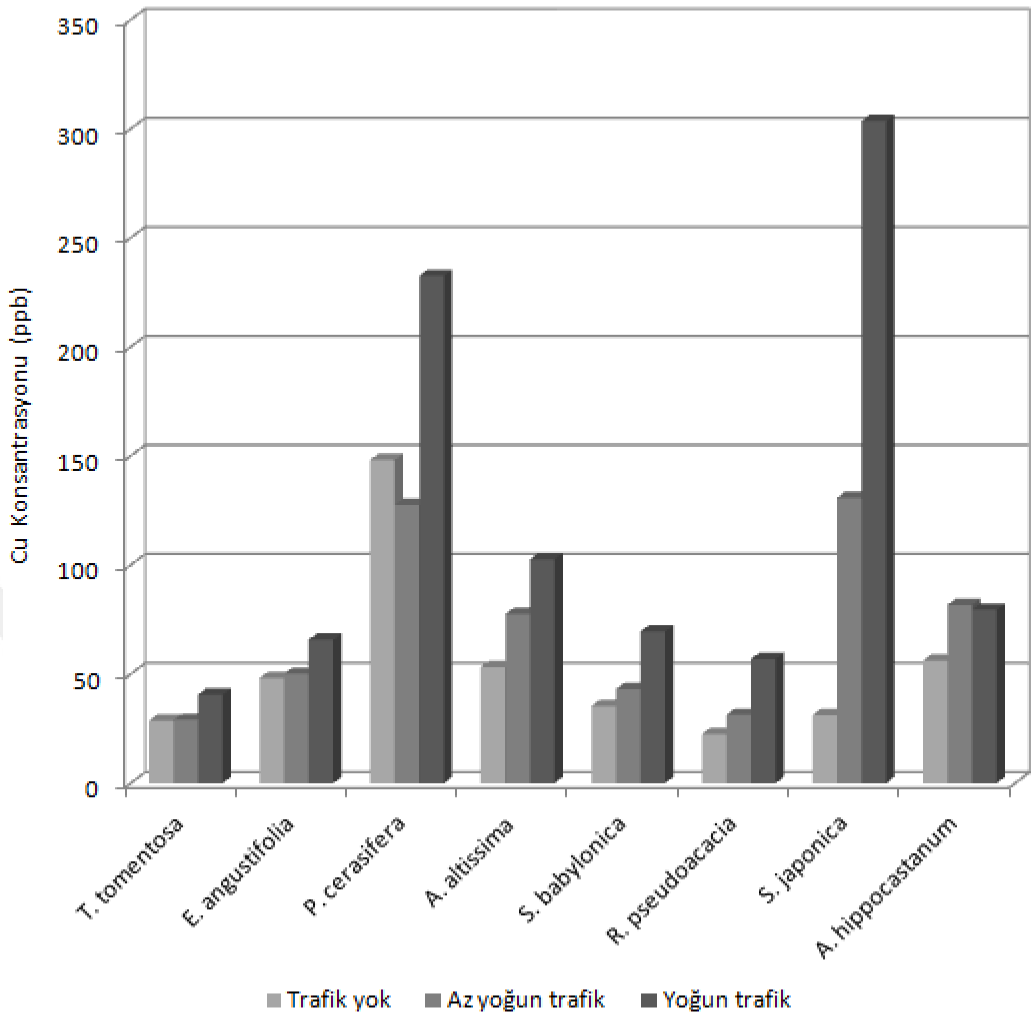


Figure 3.4. Variation of Cu Concentration Depending on Traffic Density on the Basis of the Species

When the variations of Cu concentrations depending on traffic density on the basis of species are examined; the Cu concentrations in the areas with heavy traffic is for *Tilia tomentosa* 1,417 times, for *Eleagnus angustifolia* 1,363 times, for *Prunus cerasifera* 1,569 times, for *Ailanthus altissima* 1,579 times, for Salix babylonica 1,930 times for *Robinia pseudoacacia*, 2,529 times, for *Aesculus hippocastanum* 1,415 times more than the areas with Non traffic. Whereas in *Sophora japonica*, the concentration of Cu was at 31,26 ppb in areas where there is no traffic increased to 130,853 ppb in areas where traffic was low and to 303,553 ppb in areas where traffic was heavy. In other words, the concentration of Cu in the areas where the traffic is heavy was 9,711 times more than that of the Cu concentration in areas where there is no traffic.

3.1.3 Variation of Ca Concentration Depending on Traffic Density on the Basis of the Species

Within the scope of this study, the variation of the Ca concentration depending on the plant species in areas with Non, low dense and heavy traffic was determined and the average values, the F value with significance level obtained from the analysis of variance, and the homogeneous groups formed by the Duncan test were given in the Table 3.9.

Table 3.9. *Variation of Ca Concentration Depending on Traffic Density on the Basis of the Species*

	Non	Low dense	Heavy	**F Val**
Tilia tomentosa	1,068 a	2,040 b	3,594 c	**3835,959*** **
Eleagnus angustifolia	1,044 a	1,760 b	1,794 c	**1996,499*** **
Prunus cerasifera	2,628 b	2,554 a	3,522 c	**6691,754*** **
Ailanthus altissima	1,638 a	2,389 b	4,650 c	**67168,692*** **
Salix babylonica	1,372 a	1,548 b	1,682 c	**748,539*** **
Robinia pseudoacacia	1,145 a	2,884 b	**4,546 c**	**29528,679*** **
Sophora japonica	2,930 a	3,056 b	4,360 c	**3144,665*** **
Aesculus hippocastanum	1,803 a	2,308 c	2,060 b	**1346,747*** **

As shown in the table, according to the results of variance analysis, it was determined that Ca concentration significantly differed at 99.9% confidence level, depending on the traffic intensity, for all of the species which are study subjects. According to the results of Duncan test, Ca concentration in all species formed three homogeneous groups depending on traffic density. In the case of *Prunus cerasifera*, the concentration in the areas where the traffic was low dense was in the first homogeneous group, while the value obtained in the areas without traffic was in the last homogeneous group. In addition, the value obtained in areas where the traffic is low dense in the *Aesculus hippocastanum* is higher than the value obtained in areas where the traffic is heavy. In all other species, the value obtained in the areas without traffic was in the first homogeneous group, the value obtained in areas where the traffic was low dense, and the value obtained in areas where the traffic was heavy were in the last homogeneous group.

The values obtained from areas where there is no traffic range from 1,044 ppm to 2,930 ppm. The highest values were obtained from *Prunus cerasifera* and *Sophora japonica* while the lowest values were obtained from *Eleagnus angustifolia* and *Tilia tomentosa* in areas with Non traffic. The values obtained in areas where the traffic is less dense vary between 1,548 ppm and 3,056 ppm. The highest Ca concentrations were obtained from *Salix babylonica* and *Eleagnus angustifolia* where the density of traffic was low, while the highest values were obtained from *Robinia pseudoacacia* and *Sophora japonica*. The Ca values calculated from the samples collected from areas where the traffic is heavy vary between 1,682 ppm and 4,650 ppm. The highest values were obtained from *Robinia pseudoacacia* and *Ailanthus altissima* while the lowest values were obtained from *Salix babylonica* and *Eleagnus angustifolia* in areas with heavy traffic. The graph showing the variation of Ca concentration due to traffic density at species basis is given in the Figure 3.5.

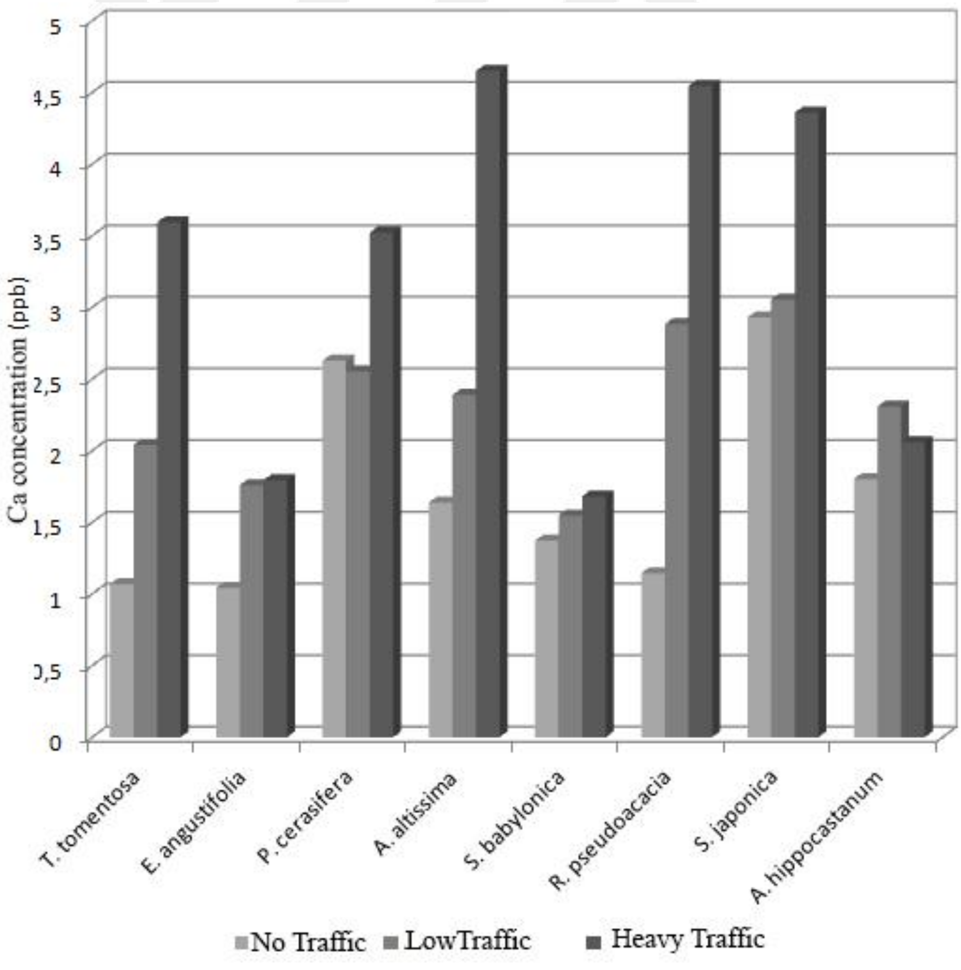


Figure 3.5. The variation of Ca concentration due to traffic density at species basis

In the figure, when the changes in species based on the traffic intensity are examined, the concentration of Ca determined in areas where the traffic is less dense was calculated 1,910 times more in *Tilia tomentosa*, 1,686 times more in *Eleagnus angustifolia*, 0,972 times more in *Prunus cerasifera*, 1,458 times more in *Ailanthus altissima*, 1,128 times more in *Salix babylonica*, 2,519 times more in *Robinia pseudoacacia*, 1,043 times more in *Sophora japonica* and 1,280 times more in *Aesculus hipp ocastanum* compared to the areas with Non traffic. The Ca concentration determined in areas with heavy traffic was 3,365 times more in *Tilia tomentosa*, 1,718 times more in *Eleagnus angustifolia*, 1,340 times more in *Prunus cerasifera*, 2,839 times more in *Ailanthus altissima*, 1,226 times more in *Salix babylonica* , 3,970 times more in *Robinia pseudoacacia*, 1,488 times more in *Sophora japonica* and 1,143 times more in *Aesculus hippocastanum* compared to the concentration of Ca determined in areas with Non traffic. According to these results, it can be said that *Tilia tomentosa* and *Robinia pseudoacacia* have the highest increases in areas where traffic is heavy.

3.1.4. Variation of Mg Concentration Depending on Traffic Density on the Basis of the Species

Within the scope of this study, the variation of the Mg concentration depending on the plant species in areas with Non, low dense and heavy traffic was determined and the average values, the F value with significance level obtained from the analysis of variance, and the homogeneous groups formed by the Duncan test were given in the Table 3.10.

Table 3.10. *Variation of Mg Concentration Depending on Traffic Density on the Basis of the Species*

	Non	Low dense	Heavy	**F Val**
Tilia tomentosa	0,373 a	0,377 a	0,390 a	**,619 ns**
Eleagnus angustifolia	0,178 a	0,320 b	0,445 c	**32,578****
Prunus cerasifera	0,586 b	0,533 a	0,636 c	**37,235*****
Ailanthus altissima	0,153 a	0,459 b	1,219 c	**1741,304*****
Salix babylonica	0,419 a	,382 a	,467 b	**12,900****
Robinia pseudoacacia	0,443 a	,479 a	,482 a	**1,698 ns**
Sophora japonica	0,669 a	,630 a	**,804 b**	**34,132****
Aesculus hippocastanum	0,456 a	,468 a	,488 a	**1,050 ns**

When the results of the tables are examined, it is seen that Mg Concentration does not significantly differ statistically in *Tilia tomentosa*, *Aesculus hippocastanum* and *Robinia pseudoacacia*, which are the subject of study, at least at 95% confidence level depending on traffic density. In all other species, Mg concentration differed at least at 95% confidence level depending on traffic intensity, and this difference was at 99% *in Eleagnus angustifolia*, *Salix babylonica* and *Sophora japonica*, and at 99.9% confidence level in *Prunus cerasifera* and *Ailanthus altissima*. As a result of the Duncan test, three homogenous groups were formed in *Eleagnus angustifolia*, *Prunus cerasifera* and *Ailanthus altissima*, while two homogenous groups were formed in *Salix babylonica* and *Sophora japonica*. In species with two homogeneous groups, the data obtained in areas where there is no traffic and where there is low dense traffic are in the same homogeneous group whereas the data obtained in areas where the traffic is heavy constitute another homogeneous group.

According to the table, in areas where there is no traffic the concentration of Mg varies between 0,153 ppm (*Ailanthus altissima*) and 0,669 ppm (*Sophora japonica*), while it ranges between 0,320 ppm (*Eleagnus angustifolia*) and 0,630 ppm (*Sophora japonica*) in areas where the traffic dense is low, and it ranges from 0,390 ppm (*Tilia tomentosa*) to 1,219 ppm (*Ailanthus altissima*) in the areas with heavy traffic. The graph showing the variation of Mg concentration depending on the traffic intensity at species basis is given in Figure 3.6.

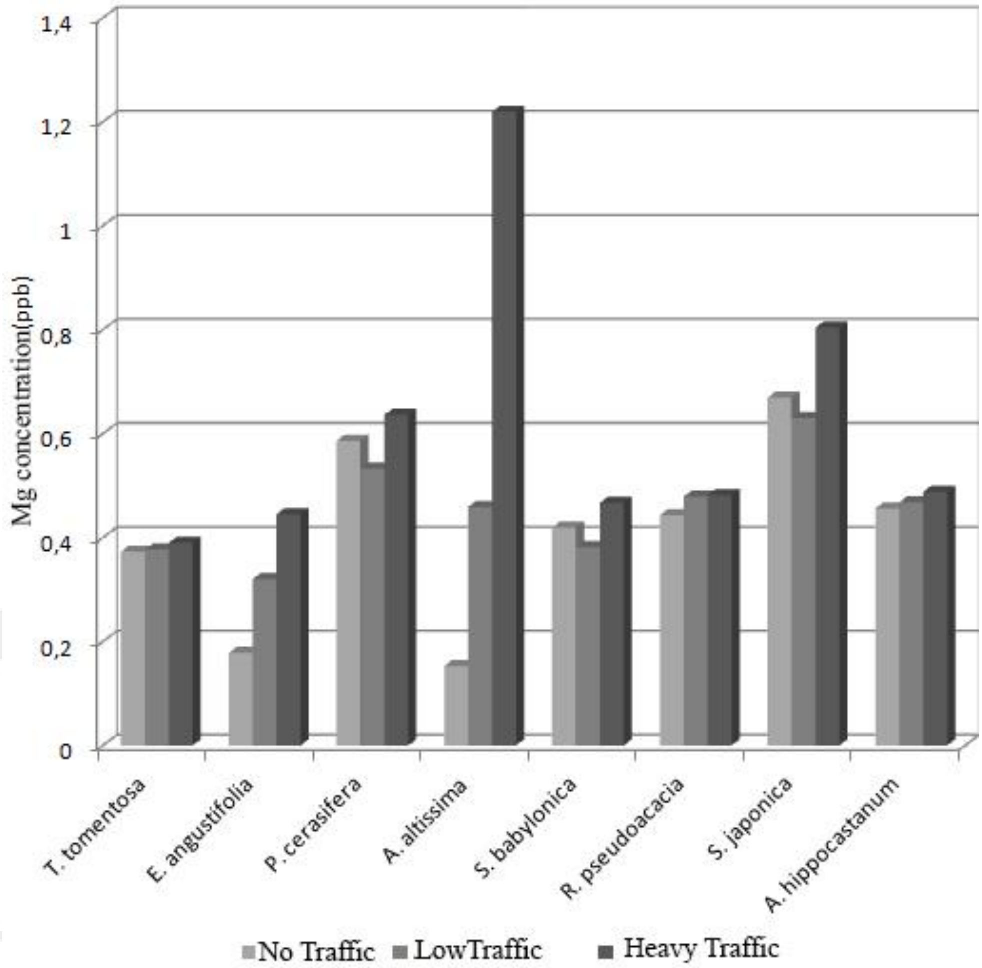


Figure 3.6. The variation of Mg concentration due to traffic density on the basis of species

Within the scope of study; according to the calculations in which the Mg concentration is significant at least at 95% confidence level depending on the traffic intensity, the concentration of Mg in the areas where the traffic is low dense was calculated as 1,978 times more in *Eleagnus angustifolia*, 0,91 times more in *Prunus cerasifera*, 3 times more in *Ailanthus altissima*, 0,912 times more in *Salix babylonica* and 0,942 times more in *Sophora japonica* than the concentration of Mg in the areas where there is no traffic. The calculated Mg concentration in areas where the traffic is less dense in *Prunus cerasifera*, *Salix babylonica* and *Sophora japonica* is lower than the Mg concentration calculated in areas where there is no traffic. However, according to the Duncan test results, the Mg concentration in *Salix babylonica* and *Sophora japonica* calculated in areas with low density traffic and the areas with Non traffic were in the same homogeneous groups.

According to the calculations in which the Mg concentration is significant at least at 95% confidence level depending on the traffic intensity, the concentration of Mg in the areas where the traffic is heavy was calculated 2.55 times more in *Eleagnus angustifolia*, 1,085 times more in *Prunus cerasifera*, 7,967 times more in *Ailanthus altissima*, 1,115 times more in *Salix babylonica* and 1,202 times more in *Sophora japonica* compared to the concentration of Mg in the areas with Non-traffic. According to this data, Mg concentration in *Ailanthus altissima* is 0,153 ppm in areas with Non traffic and increases to 0,459 ppm in areas where the traffic is less dense and increases to 1,219 ppm in areas where the traffic is dense. According to these results, the ratio of Mg Concentration in areas where traffic is low is 3 times higher than Mg concentration in areas where there is no traffic, while it is calculated that the ratio of Mg Concentration in areas where traffic is high 7,967 times higher in comparison to areas where there is no traffic.

3.1.5. Variation of Cd Concentration Depending on Traffic Density on the Basis of the Species

Within the scope of this study, the variation of the Cd concentration depending on the plant species in areas with Non, low dense and heavy traffic was determined and the average values, the F value with significance level obtained from the analysis of variance, and the homogeneous groups formed by the Duncan test were given in the Table 3.11.

Table. 3.11. *Variation of Cd Concentration Depending on Traffic Density on the Basis of the Species*

	Non	Low dense	Heavy	**F Val**
Tilia tomentosa	11,800 a	12,200 a	20,340 a	**,926 ns**
Eleagnus angustifolia	1,553 a	5,820 ab	10,280 b	**9,272***
Prunus cerasifera	2,353 a	2,433 a	7,086 b	**15,844****
Ailanthus altissima	3,120a	3,300 a	3,873 a	**1,168 ns**
Salix babylonica	29,360 a	102,106 b	123,340 c	**177,283*****
Robinia pseudoacacia	3,286 a	5,400 a	6,793 a	**2,402 ns**
Sophora japonica	3,940 a	5,493 a	4,780 a	**,370 ns**
Aesculus hippocastanum	3,653 a	5,353 a	6,593 a	**4,291ns**

When the table values were examined, according to the results of Variance analysis, it was determined that the Cd Concentration differed statistically meaningful at least at 95% confidence level only in *Eleagnus angustifolia*, *Prunus cerasifera* and *Salix babylonica* within the species subjected to the study, and this variation was at the level of 95% confidence for *Eleagnus angustifolia*, and in *Prunus cerasifera* and *Salix babylonica* this variation was found to be significant at 99.9% confidence level. The concentration of Cd in *Eleagnus angustifolia* was 1,553 ppb in areas where there was no traffic, while it was 5,82 in areas where traffic was low and 10,280 ppb in areas where traffic was heavy. In the Duncan test, the value obtained in areas where the traffic was less intense was found in the first, while the value obtained in areas where the traffic was heavy was in the second homogeneous group, and the areas where the traffic was less intense occurred in both groups. In *Prunus cerasifera*, the concentration of Cd was 2,353 ppb in areas where there was no traffic, while it was 2,433 in areas where traffic was low and 7,086 ppb in areas where traffic was heavy. Two homogenous groups were formed by the Duncan test. The value obtained from the areas where there is no traffic and the value obtained from areas where the traffic was less intense constituted the first homogeneous group, while the value obtained in areas where the traffic was heavy constituted the second homogeneous group.

As a result of the Duncan test, each of the values obtained in each type of areas with Non, low dense and heavy traffic have formed separate homogeneous groups for *Salix babylonica*. The Cd concentration was calculated to be 29.36 ppb in areas where there is no traffic, 102,106 ppb in areas with low dense traffic, and 123,340 ppb in areas where traffic is heavy. The graph showing the variation of Cd concentration depending on traffic intensity on the basis of species is given in Figure 3.7.

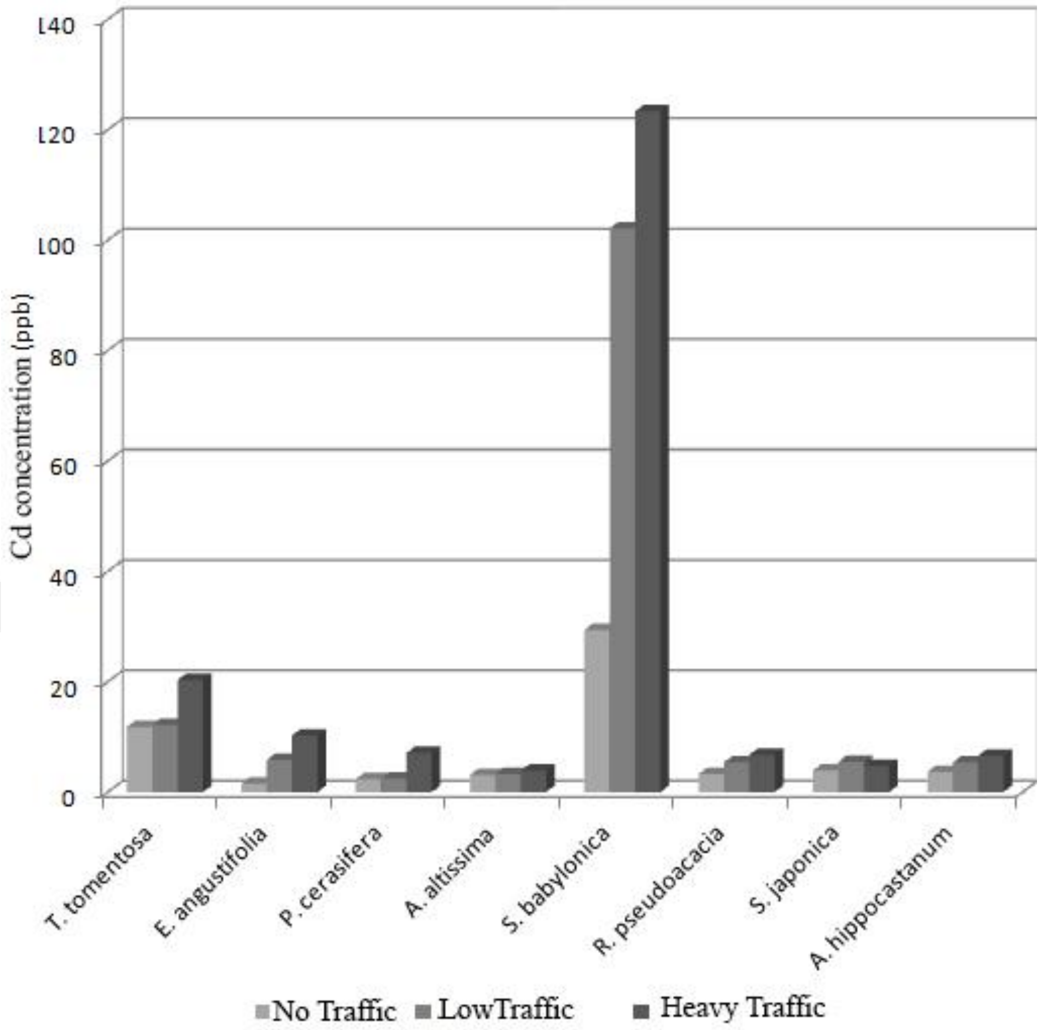


Figure 3.7. The variation of Cd concentration depending on traffic intensity on the basis of species

The figure shows the changes in the concentration of Cd depending on the traffic intensity at the species level. According to the calculations done for the species where Cd concentration is significant at least 95% confidence level depending on traffic intensity, the Cd concentration in areas with low density traffic was 3,748 times more in *Eleagnus angustifolia*, 1,034 times more in *Prunus cerasifera*, 3,478 times more in *Salix babylonica* compared to the areas with Non traffic; and the Cd concentration in areas with heavy traffic was 6,619 times more in *Eleagnus angustifolia*, 3,011 times in *Prunus cerasifera* and 4,201 times more in *Salix babylonica* than the areas with Non traffic.

3.1.6. Variation of Cr Concentration Depending on Traffic Density on the Basis of the Species

Within the scope of this study, the variation of the Cr concentration depending on the plant species in areas with Non, low dense and heavy traffic was determined and the average values, the F value with significance level obtained from the analysis of variance, and the homogeneous groups formed by the Duncan test were given in the Table 3.12.

Table 3. 12. *Variation of Cr Concentration Depending on Traffic Density on the Basis of the Species*

	Cr (ppb)			
	Non	Low dense	Heavy	**F Val**
Tilia tomentosa	23,546 a	34,860 a	24,600 a	**4,356 ns**
Eleagnus angustifolia	20,246 a	28,213 a	24,620 a	**4,943 ns**
Prunus cerasifera	10,566 a	14,800 b	23,926 c	**149,530*****
Ailanthus altissima	12,020 a	15,773 b	21,720 c	**115,651*****
Salix babylonica	18,640 a	22,246 b	31,566 c	**71,333*****
Robinia pseudoacacia	19,326 a	17,453 a	26,920 b	**42,861*****
Sophora japonica	17,246 a	60,553 c	**43,113b**	**635,229*****
Aesculus hippocastanum	30,246 a	28,400 a	28,140 a	**,942 ns**

When the results of the table are examined, it is seen that the Cr concentration does not differ at least at 95% confidence level statistically significant in *Tilia tomentosa*, *Eleagnus angustifolia* and *Aesculus hippocastanum*, which are the subjects of the study. In all other species, it was determined that Cr concentration differs significantly at 99.9% confidence level depending on traffic intensity. As a result of the Duncan test, three homogeneous groups were formed in species other than *Robinia pseudoacacia* while two homogenous groups were formed in *Robinia pseudoacacia*. In *Robinia pseudoacacia*, which consists of two homogenous groups, the data obtained in areas where there is no traffic and where there is low dense traffic are in the same homogeneous group whereas the data obtained in areas where the traffic is heavy constitute another homogeneous group. When the average values obtained are examined, it is seen that Cr Concentration increases with traffic density in species with significant difference at least at 95% confidence level except *Sophora* *japonica*. As a result, in these species, the values obtained in areas with Non, less dense and intense traffic areas are found in separate homogeneous groups. However, the data obtained from the areas where there is no traffic in *Sophora japonica* are the first, the data obtained from areas where the traffic is intense are the second, and the data obtained from areas where traffic is low are the third homogeneous group.

According to the table, the Cr concentration in areas where there is no traffic ranges from 10,566 ppb (*Prunus cerasifera*) to 30,246 ppb (*Aesculus hippocastanum*) while it ranges between 14,800 ppb (*Prunus cerasifera*) and 60,553 ppb (*Sophora japonica*) in areas with low dense traffic, and it ranges from 21,720 ppb (*Ailanthus altissima*) to 43,113 ppb (*Sophora japonica*) in areas with heavy traffic. The graph showing the variation of Cr Concentration due to traffic density on the basis of species is given in Fig.

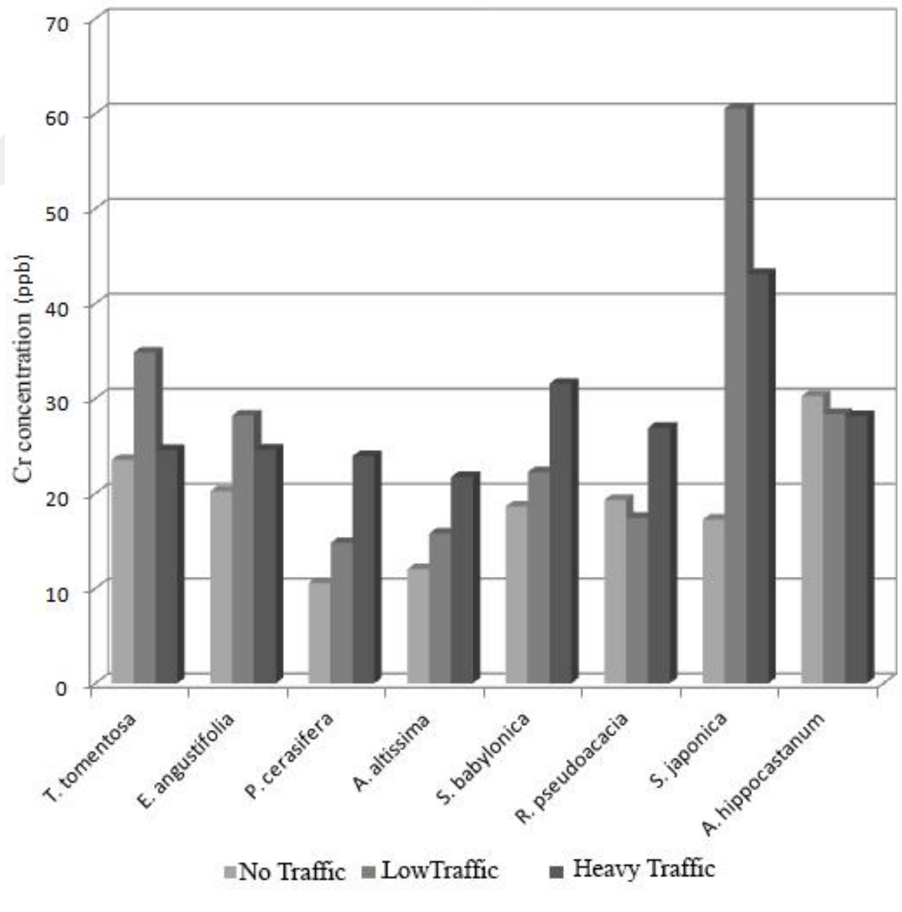


Figure 3.8. The Variation of Cr Concentration Due To Traffic Density on The Basis Of Species

Within the study; according to the calculations done for the species where Cr concentration is significant at least at 95% confidence level depending on traffic intensity, the Cr concentration in areas with low density traffic was 1,401 times more in *Prunus cerasifera,* 1,312 times more in *Ailanthus altissima,* 1,193 times more in *Salix babylonica,* 0,903 times more in *Robinia pseudoacacia,* 3,511 times more in *Sophora japonica* compared to the areas with no traffic. the Cd concentration in *Robinia pseudoacacia* is lower in low dense traffic areas than Non traffic areas. However, according to Duncan test results, the Cr concentration calculated in areas where the traffic is low dense and the Cr concentration calculated in areas where there is no traffic are in the same homogeneous groups.

According to the calculations conducted for the species in which the Cr concentration is significant at least at 95% confidence level depending on the traffic intensity, in the areas with heavy traffic, the Cr concentration was; 2,264 times more in *Prunus cerasifera*, 1,807 times more in *Ailanthus altissima*, 1,693 times more in *Salix babylonica*, 1,393 times more in *Robinia pseudoacacia* and 2.5 times more in Sophora japonica compared to the Cr concentration in the areas with Non traffic. According to this data, it can be said that the highest proportional change in Cr concentration occurs in *Sophora japonica* and *Prunus cerasifera*.

3.1.7. Variation of Ni Concentration Depending on Traffic Density on the Basis of the Species

Within the scope of this study, the variation of the Ni concentration depending on the plant species in areas with Non, low dense and heavy traffic was determined and the average values, the F value with significance level obtained from the analysis of variance, and the homogeneous groups formed by the Duncan test were given in the Table 3 13.

Table 3. 13. *Variation of Ni Concentration Depending on Traffic Density on the Basis of the Species*

	Non	Low dense	Heavy	**F Val**
Tilia tomentosa	3,553 a	6,280 b	3,880 a	**5,648***
Eleagnus angustifolia	2,953 a	3,380 a	7,906 b	**67,524*****
Prunus cerasifera	8,046 a	8,846 a	23,346 b	**58,816*****
Ailanthus altissima	2,973 a	4,853 a	7,846 a	**2,796ns**
Salix babylonica	8,366 a	10,180 b	17,600 c	**107,306*****
Robinia pseudoacacia	2,506 a	5,326 b	16,213 c	**354,737*****
Sophora japonica	4,000 a	6,020 b	6,400 c	**23,417****
Aesculus hippocastanum	1,766 a	4,826 b	5,860 b	**20,270****

When the table values are examined, the results of the variance analysis show that the Ni concentration does not differ statistically at least at 95% confidence level only in *Ailanthus altissima* from the species subject to the study, and the values obtained according to the traffic intensity in other species are different statistically at least at 95% confidence level. This difference was found to be at 95% in *Tilia tomentosa*, at 99% in *Sophora japonica* and *Aesculus hippocastanum*, and at 99.9% in other species. The lowest Ni concentration calculated in the areas with Non traffic, was obtained in *Aesculus hippocastanum* with 1,766 ppb and the highest concentration was obtained in *Salix babylonica* with 8,366 ppb. In areas with Non-traffic, the highest values were obtained with *Prunus cerasifera* with 8,046 ppb and *Salix babylonica* with 8,366 ppb, while the next highest value was obtained with *Sophora japonica* with 4,000 ppb. It is noteworthy that the Ni concentration calculated for the two species is over 8 ppb while the other six species are below 4 ppb.

The lowest Ni concentration in the samples collected from the areas with low dense traffic was calculated as *Eleagnus angustifolia* with 3,380 ppb, *Aesculus hippocastanum* with 4,826 ppb and *Ailanthus altissima* with 4,853 ppb. The highest Ni concentration was found to be 10,180 ppb with *Salix babylonica* and 8,846 ppb with *Prunus cerasifera*. The lowest Ni concentration of the samples collected from the areas with heavy traffic was calculated for *Tilia tomentosa* with 3,880 ppb and *Aesculus hippocastanum* with 5,860 ppb, while the highest values were calculated for *Prunus cerasifera* with 23,346 ppb and *Salix babylonica* with 17,600 ppb.

According to Duncan test results, the data were collected in three homogeneous groups in *Robinia pseudoacacia*, *Salix babylonica* and *Sophora japonica*, and in two homogenous groups in other species. *Eleagnus angustifolia* and *Prunus cerasifera* were in the same homogeneous group with values obtained from areas with low dense traffic and areas without traffic. While the values obtained from areas with heavy traffic were in the other homogeneous group, the values obtained from areas with low dense traffic and heavy traffic in the *Aesculus hippocastanum* were in the same homogeneous group and the values obtained from the areas without traffic were in the other homogeneous group. According to the calculations, the concentration of Ni in all species except *Tilia tomentosa* has increased due to traffic density. Only the highest Ni concentration in *Tilia tomentosa* was obtained in samples collected from areas where the traffic was low dense. In *Tilia tomentosa*, the Duncan test results show that the data obtained from areas where there is no traffic and heavy areas are in the same homogeneous group, while the values obtained from the samples collected from areas where the traffic is less dense are included in the second homogeneous group. The graph showing the variation of Ni concentration depending on traffic intensity at the basis of species basis is given in the Figure 3.9.

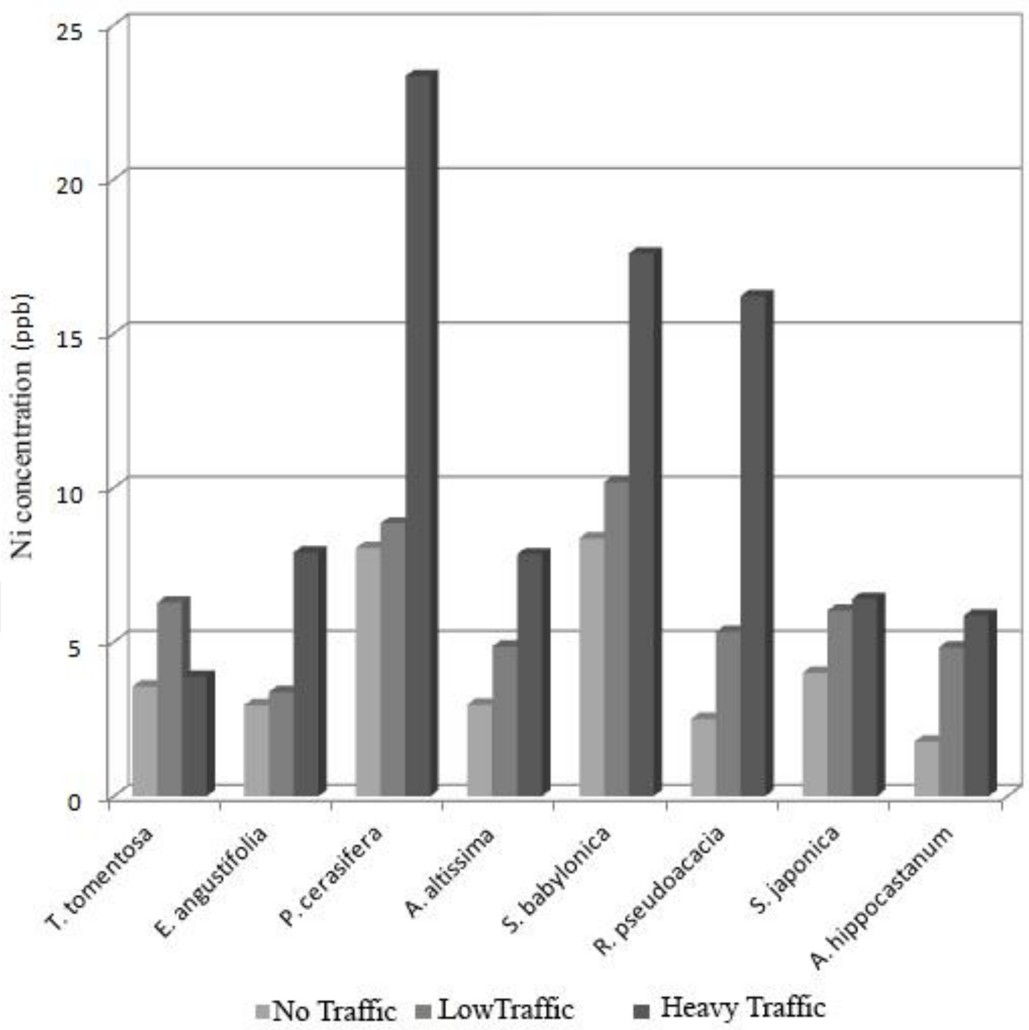


Figure 3.9. The variation of Ni concentration depending on traffic intensity at the basis of species basis

The variations of Ni concentration depending on traffic intensity at the basis of species are given in the figure. According to the calculations made in the species where the Ni concentration is significant at least at 95% confidence level depending on the traffic intensity, in the areas with low dense traffic the Ni concentration was calculated as; 1,768 more in *Tilia tomentosa*, 1,145 times more in *Eleagnus angustifolia*, 1,099 times more in *Prunus cerasifera*, 1,217 times more in *Salix babylonica*, 2,125 times more in *Robinia pseudoacacia*, 1,505 times more in *Sophora japonica* and 2,733 times more in *Aesculus hippocastanum* than the values calculated for the areas with Non-traffic. The calculated Ni concentration in areas with with heavy traffic was 1,092 times more in *Tilia tomentosa*, 2,677 times more in *Eleagnus angustifolia*, 2,902 times more in *Prunus cerasifera*, 2,104 times more in *Salix babylonica*, 6,470 times more in *Robinia pseudoacacia*, 1,600 times more in

Sophora japonica and 3,318 times more in *Aesculus hippocastanum* in comparison to the areas with Non traffic.

According to the calculations, while the Ni concentration in areas with Non traffic was 2,506 ppb, it was calculated to increase up to 5,326 ppb in areas with low dense traffic and and it draws attention with 16,213 ppb in for *Robinia pseudoacacia* in areas with heavy traffic. For this species it was calculated that the Ni concentration is 2,125 times more in areas with low density and 6,470 times more in areas with heavy traffic than the areas with Non-traffic.

3.1.8. Variation of Fe Concentration Depending on Traffic Density on the Basis of the Species

Within the scope of this study, the variation of the Fe concentration depending on the plant species in areas with Non, low dense and heavy traffic was determined and the average values, the F value with significance level obtained from the analysis of variance, and the homogeneous groups formed by the Duncan test were given in the Table.

Table 3.14. *Variation of Fe Concentration Depending on Traffic Density on the Basis of the Species*

	Non	Low dense	Heavy	**F Val**
Tilia tomentosa	8,373 a	17,373 b	19,706 c	**2024,707*** **
Eleagnus angustifolia	6,480 a	8,626 b	17,333 c	**6539,155*** **
Prunus cerasifera	13,346 b	10,493 a	25,500 c	**4256,958*** **
Ailanthus altissima	5,246 a	7,906 b	14,953 c	**1650,333*** **
Salix babylonica	4,593 a	7,860 b	13,033 c	**617,744*** **
Robinia pseudoacacia	13,546 a	13,293 a	18,780 b	**38,081*** **
Sophora japonica	9,146 a	40,573 b	54,353 c	**16847,105*** **
Aesculus hippocastanum	10,300 a	28,926 c	19,266 b	**2679,566*** **

When the table values were examined, according to the results of Variance analysis, it was determined that the Fe Concentration differed statistically meaningful at 99,9 % confidence level for all the species. According to Duncan test results, for all species except *Robinia pseudoacacia*, Fe concentration formed three homogeneous groups depending on traffic density. For *Robinia pseudoacacia*, the data were collected in two homogenous groups, while areas with low traffic density and areas without traffic were in the same homogeneous group, the areas with heavy traffic were in the other homogeneous group.

Besides, only for *Prunus cerasifera*; the Fe concentrations obtained from areas with law dense traffic were in the first homogeneous group and the values obtained from areas without traffic were in the second homogeneous group. For *Aesculus hippocastanum*, the area with low traffic density was the third and the area with high traffic density was in the second homogeneous group. According to these results, the value obtained in areas without traffic in *Prunus cerasifera* is higher than the value obtained in areas with low density traffic; in the *Aesculus hippocastanum*, the value obtained in areas with low dense traffic is higher than the value obtained in areas where traffic is heavy. Therefore, in all the species except *Aesculus hippocastanum, Robinia pseudoacacia* and *Prunus cerasifera*, the value obtained in the areas without traffic was in the first homogeneous group, the value obtained in areas with low dense traffic was found in the second homogeneous group and the value obtained in areas where traffic was heavy was in the last homogeneous group.

The values obtained in areas without traffic of Fe concentration range between 4,593 ppm and 13,546 ppm. The highest values were obtained in *Prunus cerasifera* and *Robinia pseudoacacia* while the lowest values were obtained in *Salix babylonica* and *Ailanthus altissima* in areas without traffic. The values obtained in areas with low dense traffic vary between 7,860 ppm and 40,573 ppm. The highest values were obtained in *Sophora japonica* and *Aesculus hippocastanum* while the Fe concentrations in areas with low dense traffic were lowest in *Salix babylonica* and *Ailanthus altissima*. The Fe concentrations calculated in the samples collected from areas where the traffic is heavy vary between 13,033 ppm and 54,353 ppm. The highest values were of *Sophora japonica* and *Prunus cerasifera* while the lowest values were of *Salix babylonica* and *Ailanthus altissima* in the areas where the traffic was heavy. The graph showing the variation of Fe concentration depending on the traffic density at the basis of species is given in the Figure 3.10.

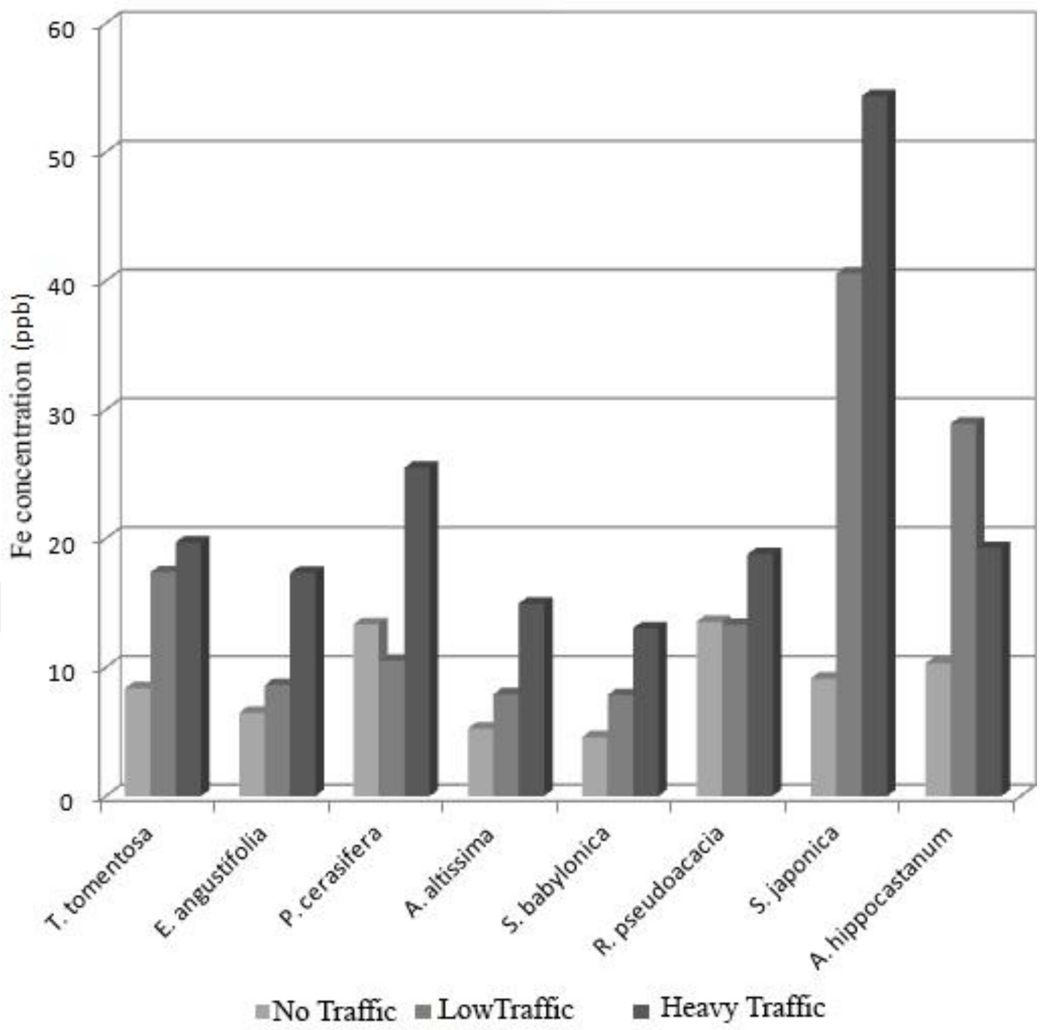


Figure 3.10. The Variation of Fe Concentration Depending on The Traffic Density at The Basis of Species

In the Figure, when the variation of Fe concentration is examined it can be seen that the values of the areas with low dense traffic is 2,075 times more in *Tilia tomentosa,* 1,331 times more in *Eleagnus angustifolia,* 0,786 times more in *Prunus cerasifera,* 1,507 times more in *Ailanthus altissima,* 1,711 times more in *Salix babylonica,* 0,981 times more in *Robinia pseudoacacia,* 4,436 times more in *Sophora japonica,* 2,808 times more in *Aesculus hippocastanum* compared to the values calculated for the areas with Non-traffic. It was calculated that the Fe concentration of the areas with heavy traffic was 2,354 times more in *Tilia tomentosa*, 2,675 times more in *Eleagnus angustifolia,* 1,911 times more in *Prunus cerasifera,* 2,850 times more in *Ailanthus altissima,* 2,838 times more in *Salix babylonica*, 1,386 times more in *Robinia pseudoacacia*, 5,943 times more in *Sophora japonica*, 1,870 times more in *Aesculus hippocastanum.*

The variation of the Fe concentration depending on the traffic density in *Sophora japonica* is remarkable. For this species it was calculated that while the Fe concentration in areas without traffic was 9,146 ppm, it increased to 40,573 ppm in the areas with low dense traffic and to 54,353 ppm in areas with heavy traffic. Which means that in *Sophora japonica*, the Fe concentration in areas with low dense traffic is 4,436 times more than the areas with Non traffic; and the Fe concentration in areas with heavy traffic is 5,943 times more than the areas with Non traffic.

3.1.9. Variation of Mn Concentration Depending on Traffic Density on the Basis of the Species

Within the scope of this study, the variation of the Mn concentration depending on the plant species in areas with Non, low dense and heavy traffic was determined and the average values, the F value with significance level obtained from the analysis of variance, and the homogeneous groups formed by the Duncan test were given in the Table 3.15.

Table 3.15. *Variation of Mn Concentration Depending on Traffic Density on the Basis of the Species*

	Non	Low dense	Heavy	**F Val**
Tilia tomentosa	2,560 a	5,960 b	6,073 b	**226,863*** **
Eleagnus angustifolia	5,713 a	5,513 a	10,720 b	**2025,624*** **
Prunus cerasifera	4,813 b	3,440 a	6,220 c	**1196,541*** **
Ailanthus altissima	4,660 b	2,946 a	12,960 c	**7934,586*** **
Salix babylonica	4,213 a	5,126 b	4,800 b	**9,167* **
Robinia pseudoacacia	3,113 a	3,533 b	5,606 c	**150,166*** **
Sophora japonica	2,506 a	6,573 b	**7,593 c**	**1494,920*** **
Aesculus hippocastanum	7,360 b	6,340 a	7,233 b	**39,891*** **

As seen o the table, according to the results of Variance analysis, it was determined that the Mn Concentration differed statistically meaningful at least at 95% confidence level depending on traffik density for all the species. This variation is at %95 confidence level for *Salix babylonica*, and at %99,9 for all other species.

According to the Duncan Test, the data depending on traffic density was gathered in three homogeneous groups for the species of *Prunus cerasifera*, *Ailanthus altissima*, *Robinia pseudoacacia* and *Sophora japonica.* Among these species the Mn concentration in the leaf samples of *Prunus cerasifera* collected from the areas with Non traffic was 4,813 ppm, while it was calculated 3,440 ppm for the samples taken from the areas with low dense traffic and 6,220 ppm for the areas with heavy traffic. A similar situation was seen *Ailanthus altissima.* The Mn concentration in the leaf samples of *Ailanthus altissima* collected from the areas without traffic was 4,660 ppm, it was calculated 2,946 ppm in the samples collected from areas that had low dense traffic and 12,960 in the samples of the areas with heavy traffic. According to the Duncan test results, data obtained from these two species were gathered in three homogeneous groups; areas with low dense traffic were in the first group, areas with Non traffic were in the second group and the areas with heavy traffic were in the first homogeneous group.

The data obtained from *Robinia pseudoacacia* and *Sophora japonica* were also gathered in three homogenous groups. However the Mn concentration has increased depending on the traffic density. The Mn concentration in the samples of *Robinia pseudoacacia* that were collected from the Non-traffic areas was 3,113 ppm, while it was calculated 3,533 ppm in the samples collected from the areas with low dense traffic, and 5,606 ppm in the samples collected from the areas with heavy traffic. And for *Sophora japonica* these values were 2,506 ppm, 6,573 ppm and 7,593 ppm respectively for the areas with Non-traffic, low dense and heavy traffic.

Data obtained from *Tilia tomentosa*, *Eleagnus angustifolia*, *Salix babylonica* and *Aesculus hippocastanum* were gathered in two homogenous groups according to the results of Duncan test. For *Tilia tomentosa* and *Salix babylonica,* data of the areas without traffic were in the first homogeneous group, while the data of areas with low dense and heavy traffic were in the second one. For *Eleagnus angustifolia* and *Aesculus hippocastanum* data obtained from the areas with Non traffic and low dense traffic were gathered in the first group, data of the areas with heavy traffic were in the second group.

Data obtained from the areas without traffic in regard to Mn concentration vary between 2,506 ppm and 7,360 ppm. While the lowest values were of *Sophora* *japonica* and *Tilia tomentosa*, the highest values were of *Aesculus hippocastanum* and *Eleagnus angustifolia*. Data obtained from the areas with low dense traffic vary between 2,946 ppm and 6,573. In the areas with low dense traffic, the lowest Mn concentration was calculated in *Ailanthus altissima* and *Prunus cerasifera,* the highest values were of *Sophora japonica* and *Aesculus hippocastanum.* Data obtained from the areas with heavy traffic vary between 4,800 ppm and 12,960. While the lowest Mn concentration was calculated in areas with heavy traffic were of *Salix babylonica* and *Robinia pseudoacacia*, the highest values were of *Ailanthus altissima* and *Eleagnus angustifolia.* The graph showing the variation of Mn concentration depending on the traffic density at the basis of species is given in the Figure 3.11.

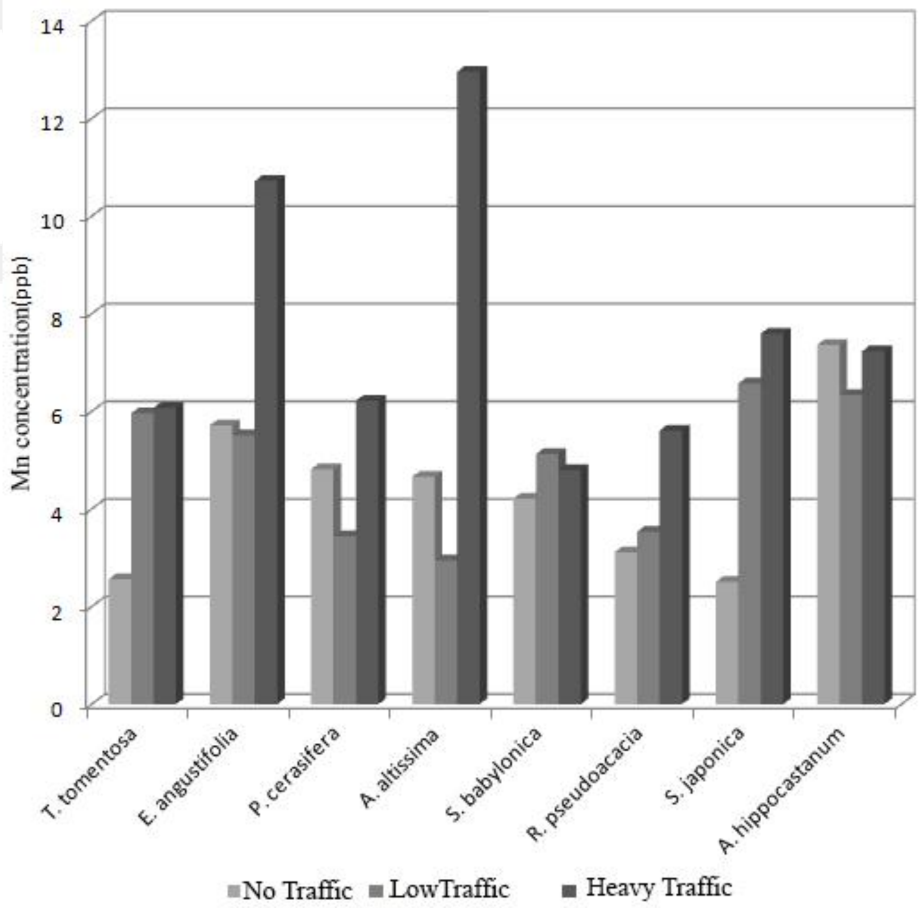


Figure 3.11. The Variation of Mn Concentration Depending on The Traffic Density at The Basis of Species

When the values on the figure are examined, it can be seen that the Mn concentration determined for the areas with low dense traffic was 2,328 times more in *Tilia tomentosa*, 0,965 times more in *Eleagnus angustifolia*, 0,715 times more in *Prunus cerasifera*, 0,632 times more in *Ailanthus altissima*, 1,217 times more in *Salix babylonica*, 1,135 times more in *Robinia pseudoacacia*, 2,623 times more in *Sophora japonica* and 0,861 times more in *Aesculus hippocastanum* than the areas without traffic. When the data examined, it can be seen that the Mn concentration calculated for the areas with low dense traffic was lower than the areas without traffic for the species of *Eleagnus angustifolia*, *Prunus cerasifera*, *Ailanthus altissima* and *Aesculus hippocastanum.*

the Mn concentration determined for the areas with heavy traffic was 2,372 times more in *Tilia tomentosa*, 1,876 times more in *Eleagnus angustifolia*, 1,292 times more in *Prunus cerasifera*, 2,781 times more in *Ailanthus altissima*, 1,139 times more in *Salix babylonica*, 1,801 times more in *Robinia pseudoacacia*, 3,030 times more in *Sophora japonica* and 0,983 times more in *Aesculus hippocastanum* than the Mn concentrations calculated for the areas with Non traffic. The Mn concentration calculated for the areas with low dense and heavy traffic were lower than the Mn concentration calculated for the areas with Non traffic.

The variety of the amoun of the Mn concentration in Sophora *japonica* is remarkable. Fort his species it was calculated that the Mn concentration in the areas with low dense traffic was 2,623 times; and the the Mn concentration in the areas with heavy traffic was 3,030 times more than the amount of the concentration calculated for the areas without traffic. According to this results, it can be stated that the best bioindicator to determine Mn contamination is *Sophora japonica* among the species subjected to this research.

3.1.10. Variation of Zn Concentration Depending on Traffic Density on the Basis of the Species

Within the scope of this study, the variation of the Zn concentration depending on the plant species in areas with Non, low dense and heavy traffic was determined and the average values, the F value with significance level obtained from the analysis of variance, and the homogeneous groups formed by the Duncan test were given in the Table 3.16.

Table 3.16. *Variation of Zn Concentration Depending on Traffic Density on the Basis of the Species*

	Non	Low dense	Heavy	**F Val**
Tilia tomentosa	2,773 a	5,246 b	7,320 c	**357,976*** **
Eleagnus angustifolia	3,560 a	5,300 b	9,253 c	**1720,189*** **
Prunus cerasifera	1,813 a	1,853 a	3,493 b	**169,475*** **
Ailanthus altissima	1,406 a	1,846 b	4,193 c	**247,536*** **
Salix babylonica	5,913 a	17,066 b	**19,273 c**	**2414,402*** **
Robinia pseudoacacia	2,733 a	5,453 b	7,660 c	**25,860** **
Sophora japonica	1,546 a	4,880 b	9,086 c	**682,479*** **
Aesculus hippocastanum	1,080 a	1,140 a	2,400 b	**735,353*** **

As seen o the table, according to the results of variance analysis, it was determined that the Mn Concentration differed statistically meaningful at least at 99% confidence level depending on traffik density for all the species. This variation is at 99% confidence level for *Robinia pseudoacacia, and* at 99,9% confidence level for all other species. According to the evaluations and calculations it was determined that the Zn concentration in the samples were increasing with the density of the traffic.

According to the results of Duncan test, the data depending on traffic density were gathering in two homogeneous groups for *Prunus cerasifera* and *Aesculus hippocastanum;* and in three homogenous groups for all other species. For the data calculated in the samples of *Prunus cerasifera* and *Aesculus hippocastanum* values of the areas without traffic and low dense traffic were in the first group and the areas with heavy traffic were in the second one. For all the rest of the species examined within the study the areas without traffic were in the first group while the areas with low dense second; and aeras with heavy traffic were in the third group.

While the lowest values in terms of Zn concentration in the aeras without traffic were obtained from *Aesculus hippocastanum* (1,080 ppm), *Ailanthus altissima* (1,406 ppm) and *Sophora japonica* (1,546 ppm), the highest ones were of *Salix babylonica* (5,913 ppm) and *Eleagnus angustifolia*'da (3,560 ppm). While the lowest values in terms of Zn concentration in the aeras with low dense traffic were obtained from *Aesculus hippocastanum* (1,140 ppm), *Ailanthus altissima* (1,846 ppm) and *Prunus cerasifera* (1,853 ppm); the highest values were of *Salix babylonica* (17,066 ppm), *Robinia pseudoacacia* (5,453 ppm) and *Eleagnus angustifolia*'da (5,300 ppm). The lowest values in terms of Zn concentration in the aeras with heavy traffic were obtained from *Aesculus hippocastanum* (2,400 ppm), *Prunus cerasifera* (3,493 ppm) and *Ailanthus altissima* (4,193 ppm) while the highest ones were of *Salix babylonica* (19,273 ppm) *Eleagnus angustifolia* (9,253 ppm) and *Sophora japonica* (9,086 ppm). The graph showing the variation of Zn concentration depending on the traffic density at the basis of species is given in the Figure.

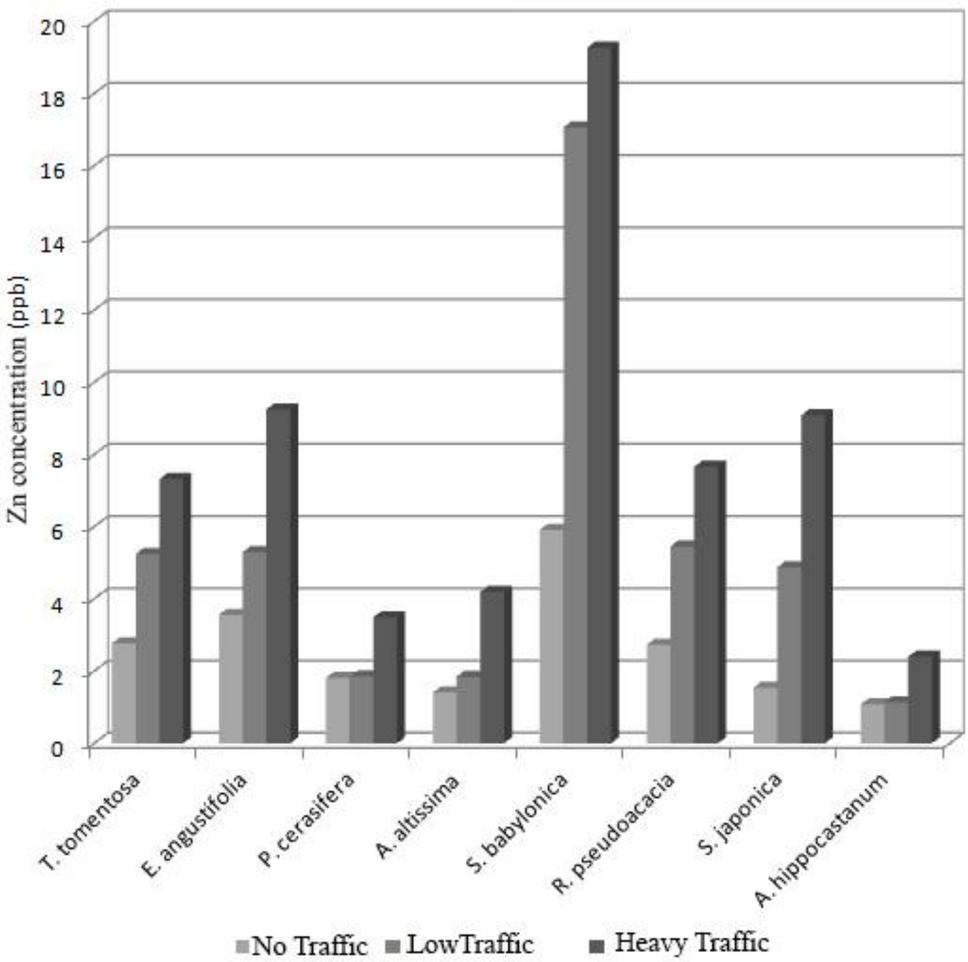


Figure 3.12. The Variation of Zn Concentration Depending on The Traffic Density at The Basis of Species

The variation of zn concentration depending on the traffic density at the basis of species is presented in the figure. When the variations are examined, it can be seen that the calculated Zn concentration in areas with low dense traffic was 1,892 times more in *Tilia tomentosa*, 1,486 times more in *Eleagnus angustifolia*, 1,022 times more in *Prunus cerasifera,* 1,313 times more in *Ailanthus altissima,* 2,886 times more in *Salix babylonica,* 1,995 times more in *Robinia pseudoacacia,* 3,157 times more in *Sophora japonica* and 1,056 times more in *Aesculus hippocastanum* than the areas of Non traffic. Comparing the values obtained from the areas with heavy traffic with the areas without traffic; the Zn concentration in the samples collected from the areas with heavy traffic were 2,640 times more in *Tilia tomentosa,* 2,599 times more in *Eleagnus angustifolia,* 1,927 times more in *Prunus cerasifera,* 2,982 times more in *Ailanthus altissima,* 3,259 times more in *Salix babylonica,* 2,803 times more in *Robinia pseudoacacia,* 5,877 times more in *Sophora japonica* and 2,222 times more in *Aesculus hippocastanum* than the areas without traffic.

The variety of the amoun of the Mn concentration according to the calculations conducted during the study in Sophora *japonica* and *Salix babylonica* is remarkable . It was calculated that the Zn concentration of *Salix babylonica* in areas with low dense traffic was 2,886 times; and the Zn concentration calculated for the areas with heavy traffic was 3,259 times more than the areas without traffic. For *Sophora japonica,* the Zn concentration in areas with low dense traffic was 3,157 times; and the Zn concentration calculated for the areas with heavy traffic was 5,877 times more than the areas without traffic. According to this results, it can be stated that the best bioindicator species to determine Zn contamination are *Sophora japonica* and *Salix babylonica* among the species subjected to this research.

4. RESULTS AND DISCUSSION

4.1. The Variation of the Amounts of The Elements Depending on Plant Species and Traffic Density

As the result of the study, it was determined that the traffic density is effective on the concentration in all the elements, the element concentration increases with the increasing traffic density. According to the results of Duncan test, it was found that three homogeneous groups were formed by the data of Pb, Ca, Fe and Zn, while the other elements were gathered in two homogeneous groups. For the elements of Cu, Ca, Ni and Mn; the areas without and with low dense traffic were in the same group while the areas with heavy traffic were in a seperate group. For the element of Cr, the areas without traffic were in a homogenous group while the areas with low density and heavy traffic were forming another homogeneous group together.

The increase of the heavy metal concentration in the plant organelles with the increase of the traffic density has been revealed in many studies. These studies use the different organelles of the plants, and the organelles being used most intensively are leaves. Due to the effective absorptive structures equipped with heavy metal retention mechanisms of leaves, metals can accumulate in plant leaves after the atmospheric particles have precipitated on leaf surfaces via leaf transfer (Xiong et al., 2014; Schreck et al., 2012). Therefore, heavy metals are determined with high concentrations in the leaves of the plants which are located close to the areas of where the air includes high amounts of heavy metal concentrations (mine sites, industrial areas, areas with intensive traffic, etc.) (Shahid et al., 2013; Xiong et al., 2014; Schreck et al., 2013). For this reason, plant leaves are frequently used in biological monitoring studies near industrial sites or roads to assess metal contamination by atmospheric deposition / transfer (Shahid et al., 2017).

Numerous studies were conducted to determine the heavy metal accumulation of plant leaves untill today. The heavy metal accumulation in plant leaves of many species such as *Elaeagnus angustifolia* (Aksoy and Şahin, 1999), *Robinia pseudoacacia* (Serbula et al., 2012; Çelik et al., 2005), *Cupressus sempervirens*

(Çavuşoğlu and Çavuşoğlu, 2005), *Cedrus libani* (Çavuşoğlu and Çavuşoğlu, 2005), *Magnolia grandiflora* (Demirayak et al., 2011), *Sophora japonica* (Li et al., 2007), *Rhododendron pulchrum* (Suzuki et al., 2009), *Alstonia scholaris, Ficus bengalensis, Morus alba,* and *Polyalthia longifolia* (Tanushree et al., 2011), *Platanus orientalis* (Sawidis et al., 2011), *Pinus nigra* (Sawidis et al., 2011), *Quercus ilex* (Gratani et al., 2008) have been subject to the researches.

As the result of the variance analysis conducted within this study, it was determined that there are statistically significant differences among the species in terms of all the elements. The lowest values according to the Duncan test results at the basis of species were found in *Prunus cerasifera* in terms of Pb and Cr, *Tilia tomentosa* in terms of Cu concentration, *Eleagnus angustifolia* in terms of Ca and Cd concentration, *Aesculus hippocastanum* in terms of Ni and Zn concentration, *Salix babylonica* in terms of Fe concentration, *Robinia pseudoacacia* in terms of Mn concentration.

The highest values were obtained from *Aesculus hippocastanum* in terms of Pb concentration, *Prunus cerasifera* in terms of Cu and Ni concentration, *Sophora japonica* in terms of Ca, Mg, Cr and Fe concentration, *Salix babylonica* in terms of Cd and Zn concentration, and from *Eleagnus angustifolia* in terms of Mn concentration. More accumulation of different element amounts in different species has also been demonstrated in many studies (Turkyilmaz et al., 2018).

The main purpose of this study is to determine the variation of the element concentrations depending on the traffic intensity on the basis of the species. Within the frame of this purpose, leaf samples of case species were collected from the areas with Non, low dense or heavy traffic and analysed to determine the variation of element concentrations and the variation depending on plant species and traffic intensity for each element were evaluated separately.

While the differences between the areas where the traffic is heavy and the areas where there is no traffic are examined, it was calculated that the concentration of Pb in *Prunus cerasifera* in areas where traffic is heavy 3.5 times more than the concentration of lead in areas where there is no traffic.

The same ratio was calculated for *Sophora japonica* for Cu concentration and it was determined that the concentration of Cu in the areas where the traffic was heavy was 9,711 times more than the Cu concentration in areas where there is no traffic. The greatest change in Cr concentration was also determined in *Sophora japonica*. In *Sophora japonica*, the concentration of Cr in areas with heavy traffic was calculated 2.5 times more than areas without traffic. According to calculations, the change in the concentration of Fe in *Sophora japonica* was also noteworthy. While the Fe concentration of this species in areas with Non traffic was 9,146 ppm, it increased up to 40,573 ppm in areas with low dense traffic and up to 54,353 ppm in areas with heavy traffic. Fe concentration in *Sophora japonica* was calculated 4,936 times more in areas with low dense traffic; and 5,943 times more than the concentration of Fe in the areas without traffic.

A similar result was obtained for Mn concentration. It was calculated that the concentration of Mn in the areas where the traffic density is low in *Sophora japonica* is 2,623 times, and the areas with heavy traffic was 3,030 times more than the areas with Non traffic. According to these results, it can be stated that *Sophora japonica* is the most suitable species for determining Mn contamination depending on traffic density.

According to the calculations conducted within the study, the variation of Zn concentration depending on traffic density is also remarkable. It was calculated that the concentration of Zn in the areas where the traffic density is low in *Sophora japonica* was 3,157 times, and the areas with heavy traffic was 5,877 times more than the areas with Non traffic. According to these results, it can be stated that *Sophora japonica* is also the most suitable species for determining Zn contamination depending on traffic density.

It was determined that the Ca concentration in areas with heavy traffic was 3,365 times more in *Tilia tomentosa and* 3,970 times more in *Robinia pseudoacacia.* The variation of Ni concentration in *Robinia pseudoacacia* is also remarkable. According to the calulations, while the Ni concentration in areas without traffic was 2,506 ppb, it increased up to 5,326 ppb in areas with low dense traffic and up to 16,213 ppb in areas with heavy traffic. It was determined that the Ni concentration in this species in areas with low dense traffic was 2,125 times; and the Ni concentration in areas with heavy traffic was 6,470 times more that the areas without traffic.

The greatest difference between the areas with heavy traffic and and Non traffic In terms of Mg concentration was calculated for *Ailanthus altissima*; that the samples from the areas with heavy traffic had 7,967 times more Mg concentration than the areas with no traffic. It was calculated that the Cd concentration in *Eleagnus angustifolia* in the areas with heavy traffic was 6,619 times more than those from the areas with no traffic.

As a brief summary, it was determined that the most suitable species for determination of the Cu, Cr, Fe, Mn and Zn changes depending on the traffic density is *Sophora japonica* among the species chosen as the cases of this study. The most suitable species among the studied species to determine various elements were as; *Prunus cerasifera* for Pb, *Ailanthus altissima* for Mg, *Eleagnus angustifolia* for Cd, and *Robinia pseudoacacia* for Ca and Ni, respectively.

It has been proposed to use different types of biomonitors of traffic-induced air pollution in different studies conducted about this subject. *Aesculus hippocastanum* was proposed for Pb and Cu (Tomasevic and Anicic, 2010; Anicic et al., 2011), *Robinia pseudoacacia* was proposed for Fe, Zn, Pb, Cu, Mn and Cd (Celik et al., 2005), *Sophora japonica* for Fe, Zn, Pb, Cu, Mn and Cd (Sawidis et al., 2001), *Salix babylonica* for Cu and Cd (Sawidis et al., 2001)

This study reveals that the plant species studied in this research are differently effective in accumulating different heavy metals, namely, each species can accumulate different heavy metals at a higher level. Similar results have been stated in many other studies (Li et al., 2014; Srivastava et al., 2015; Petrova et al., 2014; Anicic et al., 2011). In addition to the leaves of the high structured plants

(Turkyilmaz et al., 2017; Monaci et al., 2000; Anicic et al., 2011) other parts of the plants such as trunk barks (Sawidis et al.,2011; Fujiware et al.,2011), wood (Gao et al., 2015) are used as biomonitors. But the most frequently used organelles are the leaves.

4.2. Variation of Elements Depending on Traffic Density on the Basis of Species

4.2.1. Variation of Pb Concentration Depending on Traffic Density

As the result of the study it was determined that while the amount of Pb concentration varies between 3,733 ppb (*Prunus cerasifera*) and 14,580 ppb (*Aesculus hippocastanum*) in the areas without traffic, it varies between 5,733 ppb (*Prunus cerasifera*) and 17,540 ppb (*Aesculus hippocastanum*) in areas with low dense traffic and between 9,200 ppb (*Eleagnus angustifolia*) and 21,593 ppb (*Aesculus hippocastanum*) in areas with heavy traffic.

The lead is one of the metals that harms the ecological system most due to human activities. It spreads to athmosphere as a metal or compound and is toxic in all situations. It is one of the most environmentally pollutant metals. The lead has long been a very important metal for people. It can exist as in organic or inorganic form in the nature. While the inorganic form exist in the air as particles, the organic form is volatile and mostly mixes in potable water and foodstuffs. That’s why the organic form of lead has more importance on living organisms than the inorganic form of the metal (Okcu et.al., 1999).

Lead is used extensively in industrial and agricultural activities, and therefore it is quite common. Lead is not an essential element for the growth of plants. It can exist in the soil at a dose of 15-40 ppm and is not dangerous for human and plant health unless the concentration in the soil exceeds 150 ppm. However, when exceeding 300 ppm, it is potentially dangerous for human health. In plants, the lead affects cell turgor and the stability of cell wall adversely. In addition, it affects plant water regime negatively due to stoma movements and leaf area reduction. At the same time, it is held by the roots and it affects the growth of the roots, it reduces the cations and anions uptake of the plants thus it is also affecting nutrient uptake of plants (Asri and Sonmez, 2006).

Many vegetables, fruits and meat products produced especially in areas close to the city centers and industrial areas can include lead above the acceptable amounts. The process, which is applied industrially during gold refining and recovery, illegally causes the lead to be thrown into the atmosphere as oxides (Kahvecioğlu et al., 2007). In addition, gasoline containing lead is also an important lead source (Okcu et al., 1999).

Lead can pass to the soil and the atmosphere in various ways, mainly via the fumes of industrial establishments and exhaust smoke of vehicles, battery, paint, solder and waste of petroleum industry. However, in studies conducted, it has been determined that about 98% of the lead causing environmental pollution is derived from exhaust gases (Okcu et al., 1999). For this reason, lead is one of the most frequently mentioned and studied heavy metals.

Many studies to date have identified Pb concentrations in different species. Aksoy and Şahin (1999) determined the Pb concentration in washed and unwashed plant samples of *Elaeagnus angustifolia* L. In the results of the study; it was calculated that the Pb concentration on the unwashed leaves of *E. angustifolia* was avaragely 180,21 μgg^{-1} in industrial areas, 75,82 μgg^{-1} in road sides, 50,56 μgg^{-1} in city centers, 30,45 μgg^{-1} in suburbs, 16.81 μgg^{-1} in rural areas.

Tam et al. (1987) reported that while the concentration of Pb in leaves of *Bauhina varigeata* in Hon Kong was 12 $\mu g\ g^{-1}$ in washed control group, it increased up to 72 $\mu g\ g^{-1}$ in the washed leaves collected from a roadside and up to 276 $\mu g\ g^{-1}$ in unwashed leaves taken from roadsides.

Çelik et al., (2005) determined the Pb concentrations in the washed and unwashed leaves of *Robinia pseudoacacia* L. through the study they conducted in Denizli. At the results of the study they revealed that avarage Pb amount in the samples collected from industrial region was 180,85 $\mu g\ g^{-1}$, 336,55 $\mu g\ g^{-1}$ in the samples collected from the roadsides in city center, 74,86 μg g^{-1} in the samples collected from suburbs and 34,26 μg g^{-1} in the samples which were collected from rural areas.

Çavuşoğlu and Çavuşoğlu (2005) determined that the Pb contamination in the leaves of both *Cupressus sempervirens* and *Cedrus libani* increase as the city approaches. At the result of their study they also determined that *Cupressus sempervirens* can accumulate more Pb concentration than *Cedrus libani* due to the anotomical structure of its' leaves.

Demirayak et.al, (2011) studied the heavy metal accumulation in some natural and exotic plants in Samsun and they determined the amount of Pb concentration in the leaf samples that were collected from city center and suburbs of the province of Atakum. They determined that *M. grandiflora* and *A. Cyanophylla* plants have about 8-12 ppm Pb concentration whereas the leaves collected from Atakum region had approximately 3,5 ppm of Pb.

Tanushree et.al, (2011) calculated the Pb concentration in the leaves of Alstonia *scholaris, Ficus bengalensis, Morus alba,* and *Polyalthia longifolia* through the study that they conducted in Anand city of India. At the result of the study they determined 89 mg kg^{-1} of Pb concentration in the leaves of *Morus alba*, 87 mg kg^{-1} in *Polyalthia longifolia,* 76 mg kg^{-1} in *Ficus bengalensis* and 62 mg kg^{-1} in *Alstonia scholaris.*

Sawidis et.al, (2011) calculated the Pb contamination in the control group of *Platanus orientalis* samples as 2,538 μg/g in Salzburg, 2,406 μg/g in Belgrad and 2,914 μg/g in Thessaloniki, while they determined the Pb amounts in the contaminated regions as 3,703 μg/g in Salzburg, 13,748 μg/g in Belgrad and 10,440 μg/g in Thessaloniki. As for the concentration of Pb in the leaves of *Pinus nigra* they calculated 2,444 μg/g in Salzburg, 2,223 μg/g in Belgrad, 2,811 μg/g in Thessaloniki in control groups, while they revealed that the Pb amounts in the contaminated regions increased up to 2,461 μg/g in Salzburg, 14,447 μg/g in Belgrad and 12,742 μg/g in Thessaloniki.

Li et.al, (2007) compared the heavy metal contamination of individuals located in parks and roadsides within the study that they determined the heavy metal contamination of Sophora *japonica* L. leaves. At the results they found out that the amount of heavy metals in the leaves of the individuals located on roadsides are more than the ones in the parks. The Pb concentration in the leaves of *Sophora japonica* L. Located in parks were 3,86 mg kg^{-1} , while it increased up to 5,34 mg kg^{-1} in the samples of roadsides.

4.2.2. Variation of Cu Concentration Depending on Traffic Density

The highest Cu concentration calculated in the areas without traffic was in *Prunus cerasifera* (148,253 ppb); while the lowest values were of *Robinia pseudoacacia* (22,533 ppb) and *Tilia tomentosa*'da (28,726 ppb). The highest Cu concentration calculated in the areas with low dense traffic were in *Sophora japonica* (130,853 ppb) and *Prunus cerasifera* (127,593 ppb); while the lowest values were of again *Robinia pseudoacacia* (31,353 ppb) and *Tilia tomentosa*'da (29,046 ppb). For the areas with heavy traffic the highest Cu values were determined in *Sophora japonica* (303,553 ppb) and *Prunus cerasifera* (232,580 ppb) while the lowest values were again of *Robinia pseudoacacia* (56,986 ppb) and *Tilia tomentosa* (40,700 ppb).

Copper is an important element because it takes role in enzyme activation in the plant, carbohydrate and lipid metabolism (Asri and Sönmez, 2006). Many studies have been conducted on the activities of copper in the plant. In these studies, the role of copper in plant physiology has been elaborated. According to these studies it was revealed that the copper mostly generates compounds with organic materials with low molecul weight and vitamins, plays an important role in physiological events such as photosynthesis, respiration, carbohydrate disruption, nitrogen utilization and storage, cell wall metabolism, regulates xylem permeability, controls the production of DNA and RNA, and plays an iportant role in the resistance mechanism tıwards diseases. In case of copper deficiency, it is indicated that the plant reproduction is stopped and also it is stated that copper has also found in the compounds of which the functions have not been fully understood yet as well as in structure of enzymes tahat are vital (Okcu et al., 2009).

Like the lack of copper, the plant is also damaged in excess of this element. Copper is a very poisonous metal, although plant species need it in different quantities. Some of the effects of copper poisoning are tissue damage, deterioration in roots, and darkening in plant color. Other effects are loss of ion in the stem cells as a result of deterioration of membrane permeability, deterioration of the photosynthesis process as the result of DNA damage (Okcu et al., 2009).

Copper is an essential trace element for human and animal metabolism. Copper is an indispensable part of red blood cells and many oxidation and reduction processes in animals and in humans. Copper toxicity is rare. The main symptoms of acute copper poisoning are abdominal pain, nausea, vomiting and diarrhea (Kahvecioğlu et al., 2003, Asri and Sonmez, 2006).

Because copper is a material used in various fields, there are many sources of contamination that this element generates. Copper contamination is the result of human activity resulting from emissions and atmospheric deposits, use of pesticides, assessment of sewage wastes as fertilizer, coal and mineral deposits. Copper more than 100 mg / kg in soil and 15-30 mg / kg in plant dry matter has toxic effect. Copper toxicity generally occurs in plant root systems and causes damage on some physiological events such as protein synthesis, photosynthesis, respiration, ion uptake and cell membrane stability in the plant (Asri and Sonmez, 2006). In human body, lower levels of copper ions are associated with liver cirrhosis, wilson disease, systemic rheumatic diseases, kidney disorders; high levels of copper ions cause blood cancer (Hayta, 2006). Therefore, numerous studies have been carried out to determine the concentration of copper in plants and to relate it to traffic density.

Serbula et.al, (2012) determined that the Cu amount varies between 38,7 $mgkg^{-1}$ and 286,7 $mgkg^{-1}$ in their study that was conducted with the leaves of *Robinia pseudoacacia* L. Çelik et. Al, (2005) determined the Cu amount in the washed and unwashed leaves of *Robinia pseudoacacia* L. İn the study that they carried out in Denizli. As the result of the study they determined that the Cu amount in the samples which were collected from industrial region was averagely 54,306 $\mu g\ g^{-1}$, while it was calculated as 69,71 µg g^{-1} in the samples collected from the roadsides in city center, 17,189 µg g^{-1} in suburbs and 8,68 µg g^{-1} in rural areas.

Demirayak et al., (2011) stated that the avarage Cu concentration in leaves of *M. grandiflora* in Samsun province is 35 ppm. Suzuki et al. (2009) investigated the possibility of using *Rhododendron pulchrum* leaves as bioindicators in Okayama, Japan, and determined that the concentration of Cu could increase up to 22.22 mg kg^{-1} in 9 different locations.

Tanushree et.al., (2011) determined the Cu concentration amounts as 103 mg kg^{-1} in , *Morus alba,* 81 mg kg^{-1} in *Polyalthia longifolia,* 71 mg kg^{-1} in *Ficus bengalensis,* 42 mg kg^{-1} in *Alstonia scholaris* in theri stduy that was conducted in Anand city of India.

Sawidis et.al, (2011) calculated the Cu contamination in the control group of *Platanus orientalis* samples as 2,565 µg/g in Salzburg, 4,838 µg/g in Belgrad and 3,074 µg/g in Thessaloniki, while they determined the Cu amounts in the contaminated regions as 13,998 µg/g in Salzburg, 25,197 µg/g in Belgrad and 21,772 µg/g in Thessaloniki. As for the concentration of Cu in the leaves of *Pinus nigra* they calculated 3,182 µg/g in Salzburg, 3,263 µg/g in Belgrad, 2,432 µg/g in Thessaloniki in control groups, while they revealed that the Cu amounts in the contaminated regions increased up to 4,875 µg/g in Salzburg, 25,391 µg/g in Belgrad and 16,486 µg/g in Thessaloniki.

Tam et al. (1987) reported that while the concentration of Cu in leaves of *Bauhina varigeata* in Hon Kong was 19 µg g^{-1} in washed control group, and 27 µg g^{-1} in unwashed control group; it increased up to 43 µg g^{-1} in the washed leaves collected from a roadside and up to 47 µg g^{-1} in unwashed leaves taken from roadsides.

Li et.al, (2007) compared the heavy metal contamination of individuals located in parks and roadsides within the study that they determined the heavy metal contamination of Sophora *japonica* L. leaves. At the results of the study they determined that the amount of heavy metals in the leaves of the individuals located on parks were 7,76 mg kg^{-1} while it increased up to 8,45 mg kg^{-1} in the samples of roadsides.

4.2.3. Variation of Ca Concentration Depending on Traffic Density

Calcium exist in soil and plants only as a bivalent cation. It is taken from soil solution by plants (Türüdü, 1997). It has effects such as regulating the metabolism, improving the kaogulation, facilitating the processing, neutralizing the environment and satisfying the colloids (Türkmen et al., 2002).

Calcium, an essential element for plant growth and development; is a macro element that plays a crucial role in the cell growth and development process, regulation of membrane permeability, stabilization of tissues, and gaining the characteristics of plants that indicate the quality. Calcium; with an essential importance for fauna, microflora, plant and soil, has important effects on the physical and chemical properties of the soil and is a vital element for the functional and structural properties of plant cell plasma membranes. In case of calsium deficiency the characteristics which indicate the plant quality in as well as yield of plant gets negatively effected which results in decreasing the market share of the product (Tuna and Özer, 2002).

Within this study it was determined that the traffic density effects the Ca concentration amounts in plants. According to the results of the study, the Ca concentration in areas without traffic varies betweeen 1,044 ppm and 2,930 ppm. While the lowest values in areas without traffic were of *Eleagnus angustifolia* and *Tilia tomentosa;* the highest values were of *Prunus cerasifera* and *Sophora japonica.* The values obtained from the areas with low dense traffic varies between 1,548 ppm and 3,056 ppm. While the lowest values in areas with low dense traffic were of *Salix babylonica* and *Eleagnus angustifolia;* the highest values were of *Robinia pseudoacacia* and *Sophora japonica.* And the Ca values calculated of the samples that were collected from the areas with heavy traffic varies between 1,682 ppm and 4,650 ppm. While the lowest values in areas with heavy traffic were of *Salix babylonica* and *Eleagnus angustifolia;* the highest values were of *Robinia pseudoacacia* and *Ailanthus altissima.*

Many studies have been reported that calcium, an essential element in plant nutrition, is effective on yield and quality. Decreases in the calcium content of soils due to various reasons stand out especially in the generative period and effect the development of the plant negatively. Calcium fertilization can be done through soil and leaf depending on the soil conditions and the plant species.

Calcium is an stationary element in the plant and it is usually possible to get a quicker response from the calcium given through the leaves (Tuna and Özer, 2002). Thus, the amount of Ca has mostly been the subject of studies on fertilization (Demir et al., 2003; Demirtas, 2005; Yağmur et al., 2002)

4.2.4. Variation of Mg Concentration Depending on Traffic Density

At the end of the study, it was determined that the Mg concentration varies between 0,153 ppm (*Ailanthus altissima*) and 0,669 ppm (*Sophora japonica*) in areas with Non-traffic; between 0,320 ppm (*Eleagnus angustifolia*) and 0,630 ppm (*Sophora japonica*) in areas with low dense traffic; between 0,390 ppm (*Tilia tomentosa*) and 1,219 ppm (*Ailanthus altissima*) in areas with heavy traffic.

Mg exists in the form of different compounds in soil. Magnesium is a very light, white mine, that can burn with a bright light in the air. The place where the magnesium exist most in the earth's crust is the sea. Magnesium is one of the 11 essential minerals for our bodies. We have about 20-28 g of magnesium in our body, 60% in our bones and teeth, and 49% in our muscles. According to past years, people are taking less of this mineral.

It is a vital mineral. The absorption of this mineral by the instestines is very hard. Daily requirement is up to 300 mg. Excessive amounts of magnesium may cause softening of stools. As the need for this mineral increases during pregnancy and breastfeeding periods, it should be taken 100 mg more during these periods. Magnesium is required wherever energy is needed in the body. In case of magnesium deficiency constipation, cramps and muscle spasm may occur (Boğa, 2007). The plants also contain magnesium in chlorophyll and it retains energy photons from the sun. Magnesium is one of the eleven vital elements together with calcium, phosphorus, sodium, potassium, iron, zinc, copper, chromium, iodine and selenium and is perhaps the most important one of all. Since the body can not produce this mineral on its own, magnesium must be taken through nutrients (Işık et al., 2004).

As a result of environmental pollution, also with acid rain and fertilizers magnesium in the soil turns in to salts that can not be absorbed from the intestines, and their intake with nutrients decreases. Although green plants and meat have magnesium, the nuts have more of this element. Magnesium is necessary for DNA production and enzymes effective for protein and carbohydrate metabolisms to act. It liberates the energy that the ATP molecule carries to the cytochrome system. This is a key role in the energy production of cells. Magnesium deficiency causes cardiovascular heart disease, aging, and cancer (Boğa, 2007).

Magnesium in soil is being used by the plants. Magnesium is the iron of the plant world. Similar to the iron-hemoglobin relationship in human body, magnesium enters the chlorophyll structure in plants. The use of potassium and phosphorus in animal fertilizers by plants consumes magnesium, which changes the magnesium uptake ability of plants (Isik et al., 2004).

Plants intake the magnesium as Mg^{+2} ion. The plants have about 0.05 and 1.50% of it. The optimum amount of magnesium in citrus fruits varies between 0,26-0,60%. Magnesium is the central atom of chlorophyll and has vital importance in photosynthesis. For this reason, in case of magnesium deficiency, the amount of chlorophyll decreases and photosynthesis degrades. As a result, plant growth degrades and it causes yield loss. It supports the formation of fat, and takes place in protein synthesis. It supports the intake and transport of phosphorus. The first symptoms of the absence of magnesium is observed in the old leaves. The colour of leaves at the end of the shoots turns into yellow starting from the stalk and middle vein of the leaf. In case of severe lack of it the veins turn into white and the leaf falls. Leaf fall gets more severe during the autumn. The colour of fruit gets pale inside and outside, the peel gets thicker. Sugar, vitamin C and the amount of acid falls. Root development slows down. The amount of product reduces. Magnesium deficiency causes the insufficiency of zinc and manganese get more severe. In practice, Mg excess is not very common. Magnesium excess is rarely seen and prevents potassium intake. In addition, root development of trees is adversely affected by the excess of this element (Aydın, 2017).

4.2.5. Variation of Cd Concentration Depending on Traffic Density

One of the heavy metals, cadmium, is now on the agenda for being a highly toxic metal with various uses and an important role in environmental pollution. It has been revealed in 1976 that cadmium has an in vivo carcinogenic effect and was classified as Type 1 carcinogen by the International Agency for Cancer Research (IARC) in 1993 (Boga, 2007).

It was determined that Cd concentration was varying between 1,553 ppb and 29,360 ppb in areas with Non-traffic; between 3,300 ppb and 102,106 ppb in areas with low dense traffic; between 3,873 ppb and 123,340 ppb in areas with heavy traffic.

Entrance and diffusion of cadmium into agricultural soils is through industrial activities, phosphorus fertilizers, sewage sludge and atmospheric deposits. more than 3 mg / kg in soil and 1 mg / kg in plant dry matter of cadmium has toxic effect. Most of the cadmium reaching plants and soils is from airborne dust particles containing cadmium. It was measured that 0.2-1.0 mg of cadmium to the m^2 per year was added with dust precipitation in the soil around the roads where the traffic is heavy (Asri and Sönmez, 2006).

As one of the most existing and toxic metals in the environment, cadmium is a toxic element for humans, animals and plants (Boğa, 2007; Asri and Sonmez, 2006). Cadmium causes many physiological changes due to the alteration of nitrogen and carbohydrate metabolisms in the plant. It causes inactivation of enzymes, prevention of photosynthesis, causing stomatal closure, loss of water via transpiration and degradation of chlorophyll biosynthesis (Asri and Sonmez, 2006).

Cadmium is a relatively rare element and does not exist as a pure element in nature. The reason that it is a major contaminant is that it is toxic even at very low doses and and the biological half-life of it is long. Cadmium is an element mostly known for it's toxic effects in plant life. Cadmium exist in; phosphate fertilizers, detergents and refined petroleum derivatives, and their widespread use results in a significant amount of cadmium contamination. The most important cadmium sources affecting plant life are; water pipes, burning coal, fertilizers used in the seed and industrial production stages, and flue gases in the industrial production stages (Kahvecioğlu et al., 2007). It has been revealed in many studies that cadmium existence have increased due to traffic density.

Aksoy and Şahin (1999) determined that the average amount of Cd was in *Elaeagnus angustifolia* L. 3,45 μgg^{-1} in industrial areas, 1,38 μgg^{-1} in road sides, 1,11 μgg^{-1} in city centers, 0,80 μgg^{-1} in suburbs and 0.50 μgg^{-1} in rural areas. Serbula et al. (2012) revealed that the amounts of Cd in branches, leaves and roots were below the detectable limits of all organelles in their study on *Robinia pseudoacacia* L. It was determined that the avarage Cd amount was 7,367 $\mu g\ g^{-1}$ in the samples collected from industrial areas, 4,286 $\mu g\ g^{-1}$ in the samples collected from roadsides in city centers, 1,373 $\mu g\ g^{-1}$ in suburbs and 0,48 $\mu g\ g^{-1}$ in rural areas. Suziki et.al., (2009) determined that the concentration of Cd could increase up to 1,24 mg kg^{-1} in 9 different locations within their study that was conducted to research the opportunities of using *Rhododendron pulchrum* leaves as bioindicators. Li et.al., (2007) determined that the Cd concentration amount in the leaves of *Sophora japonica* L., increased from 0,08 mg kg^{-1} to 0,10 mg kg^{-1} within their study on which they found out that the Cd concentration in the samples taken from roadsides were more than the samples taken from the parks.

4.2.6. Variation of Cr Concentration Depending on Traffic Density

Chromium is used in stainless steel production, in the metallurgical industry related to the production of various solder and rust inhibitors, paint, lacquer, glass and ceramics materials, and in leather industry (Asri and Sönmez, 2006). Hexavalent chromium comprises in nature as a result of industrial oxidation of chromium-containing minerals, burning of fossil fuels, wood and paper products (Okçu et al., 2009). The intake of Cr^{+6} via air into human body can lead to nasal drainage, nose bleeds, scratching and perforation in the upper respiratory tract, as well as asthma attacks for people who are allergic to chromium (Asri and Sonmez, 2006).

Chromium exist in soil naturally. While it varies depending on the main material, usually found in soil in the amount of 5-100 mg / kg. The case of chromium presence with the amount of 100 mg / kg in dry matter is also toxic for many high plants. The chromium that reaches the toxic level in the plant prevents the seed germination of the plant. Chromium also inhibits root growth by inhibiting the division and heighting of stem cells. This reduces plant growth and development by reducing the nutrients and water taken from the soil. Therefore, it causes significant decrease in yield and quality (Asri and Sonmez, 2006).

It was determined within this study that while the Cr concentration in areas without traffic varies between 10,566 ppb (*Prunus cerasifera*) and 30,246 ppb (*Aesculus hippocastanum*), it varies between 14,800 ppb (*Prunus cerasifera*) and 60,553 ppb (*Sophora japonica*) in areas with low dense traffic and between 21,720 ppb (*Ailanthus altissima*) and 43,113 ppb (*Sophora japonica*) in areas with heavy traffic.

Sawidis et.al, (2011) calculated the Cr concentration in the control group of *Platanus orientalis* samples as 0,227 µg/g in Salzburg, 0,404 µg/g in Belgrad and 0,558 µg/g µg/g in Thessaloniki, while they determined the Cr amounts in the contaminated regions as 0,388 µg/g in Salzburg, 0,472 µg/g in Belgrad and 0,621 µg/g in Thessaloniki. As for the concentration of Cr in the leaves of *Pinus nigra* they calculated 0,386 µg/g in Salzburg, 0,333 µg/g in Belgrad, 0,621 µg/g in Thessaloniki in control groups, while they revealed that the Cr amounts in the contaminated regions increased up to 0,423 µg/g in Salzburg, 0,576 µg/g in Belgrad and 0,661 µg/g in Thessaloniki. Li et.al., (2007) determined that while the Cr concentration in the samples of *Sophora japonica* L. collected from parks were 2,62 mg kg^{-1}, the samples collected from roadsides had 3,45 mg kg^{-1} of Cr concentration.

4.2.7. Variation of Ni Concentration Depending on Traffic Density

The concentration of nickel, which is considered to be one of the absolutely necessary elements, is generally very low in agricultural soils. However, the nickel content of soils consisting of ultra basic eruptive rocks such as serpentine ranges from 100-5000 mg Ni / kg. Nickel is used in coal, petroleum, steel, alloy production, galvanizing and electronics industries. The critical toxic level in soil is 100 mg / kg, > 10 µg/ g dry matter in sensitive plants and > 50 µg/ g dry matter in semi-sensitive plants. Nickel swicthes with the enzymes and the heavy metals that are in physiological active centers of plants. Nickel is the metal structure of urease and many of the hydrogenase enzymes. For this reason, urea has toxic effects on these plants as well as plants with low nickel contents can not benefit from nitrogenous fertilizer applied as urea (Asri and Sönmez, 2006). Nickel is a possible carcinogenic element for mammals and other animals (Okçu et al., 2009)

In this study, the lowest concentration of Ni calculated in areas without traffic was obtained in *Aesculus hippocastanum* with 1,766 ppb and the highest concentration was obtained in Salix babylonica with 8,366 ppb. Nickel has been the subject of many studies on heavy metals untill today.

Tanushree et al., (2011) calculated the concentration of Ni as 67 mg kg^{-1} in *Morus alba,* 51 mg kg^{-1} *Polyalthia longifolia,* 45 mg kg^{-1} in *Ficus bengalensis* in the Anand city of India. Li et al., (2007) determined that the concentration of Ni in leaves of *Sophora japonica* L. varied between 1.63 mg kg-1 and 2.48 mg kg-1 in park and roadside trees.

4.2.8. Variation of Fe Concentration Depending on Traffic Density

Within this study, it was revealed that the Fe concentration varies between 4,593 ppm and 13,546 ppm in areas without traffic, between 7,860 ppm and 40,573 ppm in areas with low dense traffic; between 13,033 ppm and 54,353 ppm in areas with heavy traffic.

Iron has a catalytic effect on the formation of chlorophyll, participates in enzyme systems, and takes part in important biochemical and metabolic events (at storing and transporting of energy in respiration and photosynthesis). Iron, which is a coenzyme in the structure of various enzymes, is also required for the activity of important respiratory enzymes such as catalase, peroxidase and cytochrome oxidase. Iron deficiency (chlorosis) is more common in fruit trees, hanging, ornamental and shrub plants (Yağmur et al., 2002). Therefore, Fe is mostly the subject of studies about fertilizing and chlorosis in plants (Çoban et al., 2005; Başar and Özgümüş, 1999).

Fe has also been the subject of studies on heavy metals in the plant leaves. Tam et al. (1987) determined the change in Fe concentration in the leaves of *Bauhina varigata* in their study in Hon Kong. As a result of the study, the control group of the Fe concentration was 168 μg $^{g\ -1}$ in unwashed leaves, 131 μg g $^{-1}$ in washed leaves; while the Fe concentration in the samples collected from road sides resulted as 861 μg g -1 in unwashed leaves and 620 μg g -1 in washed leaves. In the study, it was determined that the concentration of Fe could rise up to 3051 μg g^{-1} in unwashed samples collected from roadsides.

4.2.9. Variation of Mn Concentration Depending on Traffic Density

It was determined that the Mn concentration varies between 2,506 ppm and 7,360 ppm in the areas without traffic, between 2,946 ppm and 6,573 ppm in areas with low dense traffic, between 4,800 ppm and 12,960 ppm in areas with heavy traffic.

Plants usually take manganese as Mn^{+2} ions. Manganese can be taken from both root and leaves. Manganese deficiency can be seen in young leaves. Particularly in broad-leaved plants, in case of manganese deficiency the colour of leaves turns yellow between the leaf veins, veins remain green. Manganese deficiency is associated with the lack of enough chlorophyll in the plants. Although manganese doesn't exist in chlorophyll compound, formation of chlorophyll decreases significantly in case of manganese deficiency (Pak, 2011).

Although manganese toxicity varies according to plant species, Mn toxicity is beginning to appear in plants containing more than 100 mg kg -1 of on a dry matter basis. Manganese toxicity occurs in the form of brown stains on mature leaves in most plants. Over time, the areas where the stains are fungated. This is a clear indication of Mn toxicity. Especially in dicot plants such as beans and cotton, these symptoms cause the shape to deteriorate in young leaves (Pak, 2011).

The symptoms of Mn toxicity, which reaches the humans through the food chain, is mainly observed in the respiratory system and in the brain. Indications of manganese poisoning are hallucinations, exhaustion, insomnia, weakness, forgetfulness and nerve damage. Manganese can also cause parkinsonism, lung embolism and bronchitis. Impotence can occur if a male is exposed to Mn toxicity for a long time (Pak, 2011).

Çelik et. Al, (2005) determined the Mn amount in the washed and unwashed leaves of *Robinia pseudoacacia* L. İn the study that they carried out in Denizli. As the result of the study they determined that the Mn amount in the samples which were collected from industrial region was averagely 786,47 µg g^{-1}, while it was calculated as 428,46 µg g^{-1} in the samples collected from the roadsides in city center, 337,36µg g^{-1} in suburbs and 271,87µg g^{-1} in rural areas.

Tam et al. (1987) determined the change in Mn concentration in the leaves of *Bauhina varigata* in their study in Hon Kong. As a result of the study, the control group of the Mn concentration was 106 µg $^{g\ -1}$ in unwashed leaves, 103 µg g^{-1} in washed leaves; while the Fe concentration in the samples collected from road sides resulted as 135 µg g -1 in unwashed leaves and 99 µg g -1 in washed leaves. In the study, it was determined that the concentration of Mn could rise up to 227 µg g^{-1} in unwashed samples collected from roadsides.

4.2.10. Variation of Zn Concentration Depending on Traffic Density

Within the study, the lowest values of Zn concentration were calculated in *Aesculus hippocastanum* as 1,080 ppm in areas with Non- traffic; 1,140 ppm in areas with low dense traffic and 2,400 ppm in areas where traffic is heavy. The highest values were calculated in *Salix babylonica* as 5,913 ppm in areas with Non- traffic; 17,066 ppm in areas with low dense traffic and 19,273 ppm in areas with heavy.

Zinc has a wide variety of important metabolic functions for plants, just like for humans and animals. In addition to its incorporation in protein and carbohydrate synthesis, it directly affects the quantity and quality of products due to its effects on enzyme activation, photosynthesis, respiration and biological membrane stability. It is an important element used in metal plating and alloys. It is also used in many industries such as ink, copy paper, cosmetics, paint, rubber, linoleum, mining industry. Zinc reaches the soil through wastewater discharged from dense industrial areas, sewage water and acid rain. The total Zn concentration in the soil ranges from 10-300 ppm, and the Zn concentration that can be taken up by plants varies between 3.6-5.5 ppm. Zn concentrations in plants are between 5-100 ppm in normal plants. The toxicities usually start after 400 ppm. In zinc toxicity, root and shoot growth of plants is reduced, roots get thinner, young leaves are curled and chlorosis occurs, cell growth and heigthing gets prevented, cell organelles are disrupted and chlorophyll synthesis is reduced (Asri and Sönmez, 2006). Some plant species have a great tolerance to zinc excess. In addition, plants react very quickly to zinc changes in the soil. Chlorosis in leaves and slowed plant growth are the first indicators of zinc deficiency. Although the effect of zinc poisonings is similar to that of other heavy metals, zinc is not as toxic as other metals (Okçu et al., 2009)

Zinc is an essential element for humans, animals and plants. It plays role especially in enzyme activities and takes place in the structure of enzymes. Its main tasks are: RNA, DNA, and protein synthesis, insulinin activation, transport and usage of the vitamin A to the cells, healing of wounds, segmentation of cells. It is also involved in many things, such as taste, sperm production, strengthening of the immune system, increased performance and behavior of learning, growth and development of unborn babies and children, and the transfer of fats in blood. However, zinc is toxic at high concentrations (Pak, 2011)

The concentration of zinc also have been the subject of many studies about heavy metals. Aksoy and Şahin (1999) determined that the average amount of Zn was in *Elaeagnus angustifolia* L. 231,26 μgg^{-1} in industrial areas, 83,52 μgg^{-1} in road sides, 69,14 μgg^{-1} in city centers, 38,16 μgg^{-1} in suburbs and 22,08 μgg^{-1} in rural areas.

Serbula et al., (2012) determined the amount of Zn in branches, leaves and roots in *Robinia pseudoacacia* L. And they revealed that the highest amount of Zn concentration was found in branches. It was determined that the amount of Zn concentration varies between 31,6 $mgkg^{-1}$ and 192,7 $mgkg^{-1}$ in the leaves of *Robinia pseudoacacia* L.

Çelik et. al, (2005) determined that the Zn amount in the samples which were collected from industrial region was averagely 456,88 $\mu g\ g^{-1}$, while it was calculated as 506,43 $\mu g\ g^{-1}$ in the samples collected from the roadsides in city center, 81,23 $\mu g\ g^{-1}$ in suburbs and 10,67 $\mu g\ g^{-1}$ in rural areas in the leaves of *Robinia pseudoacacia* L. in the study that they carried out in Denizli.

Demirayak et.al, (2011) states that the avarage Zn concentration in the leaves of *L.vulgare* in Samsun province is above 70 ppm. Tanushree et.al, (2011) reported that the Zn concentration in Anand city of India is, 83 mg kg^{-1}, in *Morus alba*, 59 mg kg^{-1} in *Polyalthia longifolia*, 49 mg kg^{-1} in *Ficus bengalensis*, 42 mg kg^{-1} in *Alstonia scholaris.* Li et.al., (2007) stated that while Zn concentration in the leaves of *Sophora japonica* L. is 20,6 mg kg^{-1} in parks, it rises up to 27,9 mg kg^{-1} in road sides.

4.3. General Review

The variation of heavy metal accumulation depending on plant species were determined within this study. As a result of the study, it was determined that heavy metal accumulation changed significantly based on the plant species. However, heavy metal accumulation can vary depending on many factors. The studies have shown that the heavy metal accumulation can vary depending on the plant species (Ozturk and Bozdogan; 2015), depending of accumulation capability of different organelles of the same plant (Tošić et al., 2016; Yabanli et al., 2014) the climatic conditions (Březinová and Vymazal, 2015), air pollution and traffic intensity (Turkyilmaz et al., 2017).

Studies have shown that the heavy metal accumulation process in plants is closely related to plant anatomic structure. Especially the size and structure of the stomata plays an active role on this stage. Stomata in plant leaves control the entry of CO_2 and water vapor to the leaves and are the organelles with highest potential to detect heavy metal accumulation in leaves (Xiong et al., 2014; Xu and Zhou, 2008). The size and density of the stomata are significantly effected by many environmental conditions (Sevik et al., 2017; Galmés et al., 2007; Pearce et al. 2006). The studies revealed that the size and density of the stomata are effected by many environmental factors (BaNon et al., 2004; Beerling et al., 1997) such as drought stress (Yang and Wang, 2001; Zhang et al., 2006; Liu et al., 2006), light (Sevik et al., 2016), salt stress (Zhao et al., 2001 (Romero-Aranda et al., 2001) and climatic conditions (Cetin et al., 2017). In fact, studies have shown that air pollution is one of the important factors affecting the structure and density of stomas (Sevik et al., 2018).

The heavy metal accumulation of plants is probably related to anatomical and physiological structures of the plants. The anatomical and morphological characteristics of plants are formed by the mutual interaction of genetical and environmental conditions (Sevik et al., 2012). Therefore, as there are great differences among species (Sevik et al., 2017), also there might be major differences in the anatomical and morphological structure between different subspecies, varieties, forms and even origins within the same species (Cetin et al., 2017) and these differences also cause the plant to react differently to external factors (Sevik et al., 2017). This situation is related to genetical structure of the plant. It is inevitable that a similar situation is possible for heavy metal accumulation capacity. Therefore, it is also possible to say that the genetical structure and the age of the plant may be effective on the accumulation of heavy metals. Thus; Shadid et al. (2017) indicate that young leaves accumulate more metal than older leaves because the upper surfaces of them are thinner.

As anatomical and morphological characters of plants are formed as a result of mutual interaction of genetical and environmental conditions, environmental factors are one of the most important factors effecting plant structure (Sevik et al., 2012). Various studies have been carried out which show that environmental factors, namely growing conditions, significantly influence the response of plants to stress factors (Topacoglu et al., 2016). It has been determined that environmental conditions cause significant changes in anatomical and physiological structure of the plants.

For example, Sevik et al. (2013) suggests that the amount of chlorophyll may differ 2-3 times than each other between leaves growing in shade conditions and leaves under intense light. Similar results have been demonstrated for other factors (Zeren et al., 2017, Cetin, 2016). Thus, plants grown under different growth conditions may have different levels of heavy metal accumulation potential.

5. RECOMMENDATIONS

Nowadays as the urban life quality has gained more importance, reducing environmental pollution is one of the most important agenda items. Air pollution can be many times higher especially in urban centers where traffic and human activities are high than in rural areas (Sevik et al., 2016). The most effective way to reduce the effects of air pollution is to increase the amount of open and green space. Because green plants play an important role in reducing air pollution (Sevik et al., 2017).

In air pollution components, heavy metals have a separate precaution. Plants are very useful in monitoring heavy metal contamination. However, in order to use plants effectively in this regard, it is necessary to know which plant can accumulate which types and how much of heavy metals. In this study, it was aimed to determine which species of plants are more appropriate as biomonitors fort he elements of Pb, Cu, Ca, Mg, Cd, Cr, Ni, Fe, Mn and Zn. In the results of the study; it was determined that *Sophora japonica* is the most suitable species for determination of Cu, Cr, Fe, Mn and Zn variation depending on traffic density. Apart from this, the most suitable species for monitoring the variations of heavy metal concentrations depending on the traffic density were *Prunus cerasifera* for Pb, *Ailanthus altissima* for Mg, *Eleagnus angustifolia* for Cd, and *Robinia pseudoacacia* for Ca and Ni respectively among the studied species. It can be stated that these species are the most suitable species for determining the change in heavy metal concentration due to traffic density. Thus these species can be recommended as the most suitable bioindicators of the specified heavy metals for the further monitoring studies.

Plants can significantly reduce air pollution. However, the effects of different species on different pollution factors are at different levels. The species with the greatest accumulation of heavy metals in this study are more effective than other species in removing heavy metals from air. Therefore, using these species, especially in industrial areas and areas with heavy traffic, may lead to more effective results in the removal of heavy metals from air.

Eight plant species were evaluated in this study. Although similar studies have been carried out on a large number of plant species, many plant species have no information about their potential of heavy metal accumulation. However, studies have shown that there are huge differences between the potentials of heavy metal accumulation of plant species. Therefore, it is necessary to determine the types of plants that are not mentioned in the studies and which can be more effective in monitoring and reducing heavy metal pollution. In this respect, studies have focused especially on lichens, algae and woody taxons, and few studies have been conducted on plants such as bush species, ground covers, seasonal flowers and so on. Therefore, it can be suggested that similar studies should be continued and diversified.

Within the scope of this study, measurements were only conducted on only the leaves of certain species. However, studies have shown that some species can accumulate more amounts of heavy metals in different organelles such as wood, bark, fruit etc.. Therefore, the low heavy metal concentration in the leaves of one plant may not mean that the plant does not accumulate heavy metal. The same plant may be accumulating heavy metal accumulation in another organelle. Therefore, including other organelles of the studied plants in further studies in this area may provide important results.

Within the scope of the study, it was determined that the traffic density increased the accumulation of heavy metals in plants considerably. The heavy metals accumulated in plants are getting away from the air and do not pose a risk for human health. However, as explained above, the accumulation of heavy metals in other organs is also a matter of question. It is known that various organelles of some plants, which grow especially in areas where traffic is heavy, are consumed as food. For example, in addition to the fruits of trees such as apples, plums and mulberries grown in city centers, various organelles of plants such as sage, thyme and cabbage are also used as food. However, the number of studies on the accumulation of heavy metals in the organisms used as food for these plants grown in areas where the traffic is heavy is rather limited, and consumption of these plants as food may lead to serious health problems. For example, in this study, it has been determined that some heavy metals such as Pb, Cd and Zn in the leaves of *Tilia tomentosa* are at least twice as concentrated in areas where traffic is heavy compared to areas where there is no traffic. Therefore, it is very important to study and determine the risks in this regard.

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