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ASSESSING THE HEAVY METALS BIOACCUMULATION OF *Pinus brutia* TEN. URBAN TREE IN DUHOK, KURDISTAN REGION OF IRAQ

DIREEN J.M. ALBEYBONI* and SAMI M.A. YOUSSEF**
*Dept. of ,Forestry, College of Agriculture, University of Duhok, Kurdistan Region-Iraq.
** Dept. of ,Recreation and Ecotourism, College of Agriculture, University of Duhok, Kurdistan Region-Iraq.

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ABSTRACT

Worldwide modern urbanization generates with a wide range of environmental challenges affecting adversely on human health and well-being such as emission of air pollutant particles. Nowadays in Kurdistan Region context, most cities are in a rapid urban development, thus they eventually effect on the urban environment quality through raising the level of air pollution. Furthermore, both scientific communities and political decision-makers have taken a little attention to the role of trees as heavy metal bioindicators of air pollution. Therefore, the main goal of the present study is to assess both how the heavy metals are spatially distributed within different urban areas and emphasize on the important role of the urban forest in improving human health in Duhok province. The current study evaluates the bioaccumulation of some heavy metals (lead, cadmium and copper) by urban tree leaves (*Pinus brutia*) that are randomly distributed. Localities have been selected according to the following categories: city Centre, highways, peri-urban areas, and natural areas. For the determination of heavy metals bioaccumulation in both soil and leaves the protocol of (Martens & Lindsay, 1990) were followed. The results highlighted that the Pine tree is a successful bioaccumulator for heavy metals in Duhok urban areas. Moreover, the tree leaves take up and accumulate more heavy metals than soil. It was also shown an elevated levels of heavy metals in both soil and plant leaves with the increase in urbanization and crowdedness. Interestingly, the heavy metals investigated in tree species and soil were above the safe ranges in most urbanized locations, particularly in highway and city center. In this regard, the green spaces in general and safety greenbelt in particular should become an essential part in any urban design. However, more studies and investigations are required to show the effectiveness of other tree species as bioaccumulators in order to provide them in our urban areas to accumulate heavy metals and minimize the level of air pollution in Duhok city.

KEYWORDS: *Urban planning, Greenspace, Pinus brutia, Safety greenbelt, Bioindicator, Heavy metals*.

1. INTRODUCTION

Urban forestry has been emerged in the developing world in response to advocate the important role of trees as a critical part of the urban infrastructure, as well as to reduce the pressure growing lately on green urban areas (Konijnendijk & Gauthier, 2006; Konijnendijk, 2018). Previously, urban greeneries were mainly considered as aesthetic element s, although nowadays they are known for their functional roles in various aspects i.e. positive impact on the environment as well as providing social and economic benefits (Helm, 2002; Nilsson *et al*., 2001). In the current conditions, the urban vegetation is a vital component of urban ecosystems for enhancing the quality of life, health and well-being of citizens, climate regulation, protecting urban wildlife, recreational activities, community involvement, initiatives and actions (Dadvand *et al*., 2012; Rouquette *et al*., 2013; Weber *et al*., 2014; Hernandez, *et al*., 2018).

Over the last few decades, the human population in urban areas has rapidly increased, and as a consequence, the green areas are converted to buildings and infrastructures (Nilsson *et al*., 2001). As urban areas expand the role of trees in improving the quality of environment becomes more important (Nowak, 2006). In this context, urbanized areas are experiencing higher air and heavy metal pollution as compared to undeveloped areas (Muller *et al*., 2010; Miller, *et al*., 2015). The quality of an urban environment is directly affected by atmospheric pollution, which constitutes one of the major problems to human health (Miller *et al.*, 2015). In modern urbanization, the motor vehicle traffic is one of the main leading causes of air pollution besides the industrialization (Lombi *et al*., 2001; Dogan *et al*., 2014; Akhtar & Palagiano, 2018; Rajé *et al*., 2018). Among these air pollutant elements, heavy metals are omnipresent pollutants and the most dangerous and significant source of air pollution in urban areas (Herath, *et al*., 2018; Pulford & Watson, 2003; Viippola *et al*., 2018). These heavy metals constitute a very heterogeneous functional group of elements (Rajeswari & Sailaja, 2014; Gjorgieva, 2018). From toxicity standpoint, the heavy metals (particularly, lead, arsenic, cadmium, chromium and mercury) have caused acute and chronic poisoning exposure to human health as well as to micro- and macro-organisms as well (Järup, 2003; Popescu, 2011; Tchounwou *et al*., 2012; Rajeswari & Sailaja, 2014; Mahurpawar, 2015; Gjorgieva, 2018).

In an urban environment, the greening landscapes contributes significantly to human health improvement and well-being (Clark *et al*., 1997; Pauleit, 2003; Hernandez *et al*., 2018), and thus should be an integrated part of a city's infrastructure (Wolf, 2003; Young, 2011; Salbitano *et al*., 2016; Bianconi & Filippucci, 2019). However, the unceasing increases on human population demography often lead to uncontrolled urban expansion and generate serious air pollution problems in cities (Harish, 2012). By way of illustration, Iraq has challenged big issues in environmental pollution due to the production of numerous amount of pollutants (Jassim *et al*., 2014). They reported that the number of vehicles has risen from 2007 to 2013 by 437%, which was accompanied by an increase in the emitted amount of daily pollutants (Jassim *et al*., 2014). In Kurdistan Region, the cities of are in a vast urban development (Kurdistan Regional Government, Ministry of Planning, 2012; Jassim *et al*., 2013) with an dramatic increase in air pollution from 2012 to 2016 due to an increase in number of automobile by 38% as well as in the quantity of mass particulate by 53% (Jassim, 2019). Despite of the recent worldwide progress on the important role of urban green area, however, both scientific communities and political decision-makers have paid a little attention to higher plants role as bioaccumulators to reduce the heavy metal air pollution in Kurdistan Region (Amjadian *et al*., 2016; Janger, 2012; Khorshid & Thiele-Bruhn, 2016). Therefore, the objectives of this paper are to (i) assess the effectiveness of tree leaves as bioindicators of heavy metal pollution in urban areas of Duhok city correlated to the environment quality and human health; (ii) the concentration of deposited heavy metal elements from roadsides at different city categories. An evaluation of the necessity to the formation of "green safe belt" from roads as it will be of great importance to be implemented in future urban planning design.

2. MATERIALS AND METHODS

2.1. Study area

This study was carried out in urban areas throughout Duhok city in the north of Kurdistan Region of Iraq (N 36˚ 52′ 03″ E 42˚ 59′ 34″). Duhok city is situated on 430-540 m above sea level (asl) covering about 107 km² (Mohammed, 2013). Currently, Duhok population is approximately about 1,133,627 inhabitants (NCCI, 2015) which consist of multicultural and multiethnic communities (Mohammed, 2013). It poses a strategic location and an intercultural exchange center, since it locates at the junction of Iraqi, Syrian and Turkish borders (Mustafa, *et al*., 2012). From a landscape structure standpoint, this remarkable city is within a valley bordered by two chains of foothills i.e. Bekher from West and Zawa from East (Duhok Governorate Urban Planning Directorate, 2007; Mustafa *et al*., 2012; Omer, 2015). From a climatological standpoint, Duhok has a Mediterranean climate cold and raining in winter while warm and dry in summer (Muhamed, H.,*et al*., 2018). The temperature starts to increase gradually until reaches the highest degree, up to (37.5 ^{0}C) during July (Mohammed, 2013; Muhamed, H. *et al*., 2018). Its geographical location between the Mediterranean, Irano-Anatolian, Caucasian, and Mesopotamian semi-arid region of the city is the main reason for the temperature degree contrast. Although northern and north-west wind is the dominant wind in the area, but the direction changes toward the south-east (Mustafa *et al*., 2012; Mohammed, 2013).

2.2 .Study species *Pinus brutia* Ten.

Tree species is well-known example for their effective uses as a bioindicator of environmental pollution in urban areas (Markert, 1995; Aksoy *et al*., 2000; Sawidis *et al*., 2001; Pulford & Watson, 2003; Dadea *et al*., 2016). In this research study, the native tree species *Pinus brutia* has been used in the field experiment. It is the only native pine tree species in Kurdistan Region of Iraq (Townsend & Guest, 1966). It forms a small natural pine forest from Zawita to Atrush town, representing a relict boundary of the southern limits of the species distribution in the eastern Mediterranean region (Shahbaz, 2010). It has a well natural regeneration percentage in the open canopy and/or with dense litter (Muhamed *et al*.,2018). Nevertheless, the Zawita natural forest is affected by significant anthropogenic activities leading to denuded large areas of the natural forest. Zawita pine is one of the most well-adapted tree species to the Mediterranean-type climate such as Duhok city climate; it is an obligate seeder, a light-demanding species, tolerant to drought and poor soils (Abido, 1982). Zawita pine has been expansively planted in Kurdistan region and even outside its natural distribution all over Iraq for the purpose of urban revegetation such as roadsides, public parks, and urban gardens establishment.

2.3. Sample surveying

Toward achieving the objectives and goals being placed, a number of locations have been selected mainly according to traffic pollution gradient (taking into consideration the degree of traffic jam and car congestion) within Duhok governorate. Therefore, samples were taken from the city center, highways (Malta highway and Shindukha highway), peri-urban and from controlled areas (areas almost devoted from cars and other anthropogenic pollutant sources). Consequently, eighteen locations Figure 3 were selected on Duhok city map which represents all urban and a peri-urban areas of the city. They were localized as follow: four locations on Shindukha highway, three on Malta highway, four at peri-urban area, three from the center of the city and four were taken from controlled areas.

2.4. Samples collection, laboratory analysis of plant and soil samples for determination of heavy metals Bioaccumulation

The samples were taken from both leaves of *P. brutia* trees and from the soil at the same point during May 2018 in both Duhok city and the controlled areas (Zawita, Swaratuka, Bablo and Sharya). Leaves (Needles) of *P. brutia* were collected from five branches of each tree from a side facing the street; while the soil samples were taken at least from three points under the selected trees at (0-20 cm) after cleaning the surface from wastes and litters. The samples were kept in plastic bags, and field required information (e.g. date, location, longitude, latitude, etc.) were written on the bags. Then, all samples were taken to the laboratory of the Environment Directorate of Duhok city for analysis. All the samples were documented and numbered according to their environmental conditions as well as their locations. Knowing that for soil and leaves preparation and analyses the protocol of (Martens & Lindsay, 1990) were followed. Leaves were washed with tap water then with distilled water. After washing, the leaves were placed in the oven at (60 ^{0}C) for 48 hours. Thereafter, the dried leaves grinded with grinding machine to soft powder and stored in clean baby jars. In parallel, the soil samples were dried at room temperature, while, samples with moisture content were placed in the oven overnight at 60^{0}C. All soil samples were sieved by a mesh sized 2 mm. Furthermore, they were grinded and turned to a soft powder by the grinder and stored in clean baby jars.

The digestion of the leaves and soil is very similar, and the heavy metals analysis process was followed the procedure used by (Martens & Lindsay, 1990): 0.5 gram of dried and powdered of each sample were placed in a volumetric flask; then 5 mL of concentrated H2SO4 for leaves samples and 3 mL of concentrated HNO3 for soil samples were added and swirled carefully; the flask were placed on the hot plate, and then after the glass funnel was installed on the neck of the flask inside the digestion apparatus. The temperature was slowly increased up to (145 C°) for 1 hour. After that adding 5 mL of tri-acid mixtures (Mix grade concentration HNO 3 and HClO 4 in 9:4 ratios) heated to (240 C°) for 1 hour as well. The samples were left to cool down in the laminar air flow. Then, filtered through Whatman No. 42 filter paper and the volume were brought to 50 ML by deionized water. Lead, Cadmium and Copper were determined by Atomic Absorption Spectrophotometer

The calculation was made according to the following equation: (Martens & Lindsay, 1990)

Trace elemental (ppm) = ppm Trace elemental (from calibration curve) × V/Wt

Where: V = Total volume of the plant digest (mL); Wt= Weight of dry plant (g)

2.5. Heavy Metals

2.5.1. Lead (Pb)

Lead is a naturally occurring bluish-grey lustrous metal (Tchounwou *et al*., 2012; Zhou *et al*., 2019). It is one of the most widely distributed trace metals (Das *et al*., 2018), nowadays most of the presented lead is due to anthropogenic activities e.g. agriculture, industry, leaded gasoline domestic applications (Tchounwou *et al*., 2012; Zhou *et al*., 2019). However, lead has no confirmed biological roles but its toxicological manifestations are well known via the accumulation in both individuals and the whole food chains (Flora *et al*., 2012; Fahr, *et al*., 2013; Al-Fartusie & Mohssan, 2017). As a result, it affects different organs in the human body (ATSDR, 2017) e.g. liver, kidneys, reproductive system, endocrine system, central nervous system and hematopoietic system.

2.5.2. Cadmium (Cd)

It is a silver- white, lustrous, very soft metal, naturally occurs in the earth's crust (EPA, 2000; WHO, 2000; Orisakwe, 2012; Sharma *et al*., 2015). In addition, Cadmium found in ores containing lead, copper and zinc (Bernhoft, 2013; Sharma *et al*., 2015). It's usually used in different industrial and agricultural activities (WHO, 2000; Järup & Åkesson, 2009; Tchounwou *et al*., 2012; Bernhoft, 2013). Cadmium is considered a highly soluble metal making it more readily absorbed by plants and accumulates in edible parts (Farid, 2015). Furthermore, human exposure is whether by inhalation and cigarette smoke or ingestion of food, working in cadmium-contaminated places and eating contaminated foods (EPA, 2000; Maret & Moulis, 2013).The bioaccumulation of cadmium in the human body causes acute and chronic intoxications due to biomagnification (Hayes, 2007; Polykretis *et al*., 2019).

2.5.3. Copper (Cu)

It is a reddish-brown metal, resistance to ductility, corrosion, and malleability. It presents in the earth crust and occurs naturally in air, food, soil, water and rocks (Bull, 2010). It is an essential and widely used material by living organisms, yet it's toxic like all heavy metals (Gjorgieva *et al*., 2010). Currently, it's applied in agriculture (Xiong *et al*., 2010) and industries in several countries (Han *et al*., 2006). It spreads in the environment by human activities and natural sources like wind-blown dust, volcanoes, forest fire, decaying vegetation and sea spray (Bhavani & Sujatha, 2014). However, Copper does not break down in the ecosystem but it mainly accumulates in animal and plant bodies when found in soil (Angelova *et al*., 2010). As a result, plant diversity is relatively low near copper-disposing sources. The harmful effects of copper vary due to the way and amount of exposure (Bull, 2010). High exposure of copper to human can damage the kidneys and liver (Mahurpawar, 2015).

2.6. Statistical analysis

In this project study, the data has been analyzed by using R software computer program (R Development Core Team, 2018). To determine the significance of the differences between localities, categories, and sites Student-Newman-Keuls (SNK) statistical tests have been performed, comparing heavy metal contents at different localities. This statistical test (SNK) is derived from Tukey but it finds more differences for comparisons under consideration. The level by alpha default was 5%.

3. RESULTS AND DISCUSSION

3.2. Bioaccumulation of heavy metals by *P. brutia* and soil in Duhok city

The current study supports the previous research idea that both tree plants and soils in urban areas are generally polluted with heavy metals (Singh *et al*., 1997; Liu *et al*., 2007; Khan *et al*, 2011;). In the current study, the concentration of three heavy metals (Pb, Cd and Cu) for *P. brutia* species at Highway, City center, Peri-urban and natural areas are presented in Table (1). The data for all elements show elevated levels in soil and plant leaves with an increase in urbanization and crowdedness. These findings are consistent with those of Celik *et al*. (2005) who found the degree of heavy metals accumulation is proportional to urbanization. In addition, recently (Janger, 2012) found high levels of heavy metals concentration in Duhok-Zakho highway. Besides the activities of industrial areas and the density of traffic in urban roadsides considered major reasons behind the elevated levels of heavy metals.

Interestingly, the results of Pb, Cd, and Cu investigated in tree species and soil were above the safe ranges (table 3 and 4) in some sites based on (Kabata-Pendias & Pendias, 2001; WHO, 1996). According to the toxicity table of Kabata-Pendias & Pendias (2001), the major samples of highway and City Center in Duhok area are above permissible levels, some of them are dramatically toxic. For peri-urban samples, the level fluctuated with low and high heavy metal levels; while most control samples are within the safe level. The obtained results (Table 2 and Figure 1& 2 a,b,c) shows surprising differences in the ratios between the urbanized areas and controlled sites. the results agreed with previous ones highlighting the urban areas are more polluted than rural and natural areas (Khattak & Jabeen, 2012; Sawidis *et al.*, 2012; Mansour, 2014). By way of illustration, in the present study the average rate of Pb in Pine leaves was 43.6 and 42.17 ppm in CC and HW respectively that considered toxic according to the permissible range of (Kabata-Pendias & Pendias, 2001). While, the average concentration for natural and per-urban were 4.4 and 8.7 respectively (Table 2), that considered safe (Kabata-Pendias & Pendias, 2001).

The heavy metals (Pb, Cd, Cu) accumulation in leaves of Zawitta Pine and soil are shown in figure (1 & 2 and table 1& 2). More interesting results was that *P. brutia* uptake the highest value of heavy metals (Pb and Cd). The overall measurement results have shown the value of Pb ranged between 2.95 and 120.75 ppm. According to (Kabata-Pendias & Pendias, 2001) research, the level of Pb in many locations considered contaminants and ranged within the toxic level. The most surprising result emerged from the data is the value of Pb in *P. brutia* leaves 120.75 ppm recorded on the Highway (HW2) point, followed by 73.44 ppm in city center (CC2). The highest value was found near the roadside (HW); it seems that these results are due to the nature of Pb as it is less mobile than other heavy metals (Koeppe, 1981; Orisakwe & Öztürk, 1997) . In addition, the present finding support previous studies which concluded that the coniferous trees are more useful in accumulation of particulate matter (PM) than broad-leaved trees (Beckett *et al*., 1998; Sæbø *et al*., 2012; Alahabadi *et al*., 2017; Albeyboni, submitted 2019).

Regarding to Cadmium, the values set within 0.25 and 9.02 ppm for control and Highway areas respectively (Table 1). According to (Kabata-Pendias & Pendias, 2001) the level of Cd in almost all urban locations considered above the safe levels (Table 3). The highest value of Cd are found in a highway in the vicinity of roadside and traffic intensity followed by CC then the concentration decreases considerably at Purb (Figure1). Cd in *P. brutia* for HW and CC, as the mean values are 3.57 and 3.36 ppm respectively the rate is considered high compared with Control mean value (0.43 ppm). The Cd rate obtained from the current study as the value descending from Highway to less contaminated areas were inconsistent with (Bakirdere & Yaman, 2008; Sulaiman & Hamzah, 2018). This decrease in the levels of cadmium along with the distance from the main roads shows that motor vehicle emissions play a remarkable role of fluctuation in Cd levels (Bakirdere & Yaman, 2008).

The rate of Cu in the different sites within the four categories (Control, Purb, CC, and HW) are represented in table 1. The results obtained from Pine leaves analysis show the value of Cu ranged between 6.73 and 32.76 ppm for the categories. According to Kabata-Pendias & Pendias (2001), the safe range of Cu lays within 5-30 ppm. Based on this, the range level in trees is considered risky in some locations. The mean value of Cu in *Pinus* for Control, Purb, CC, and HW is 5.74, 22.15, 12.56 and 16.62 ppm respectively as shown in table 2. Consequently, most of urban locations are above the safe range and considered risky for human. These toxic level of Cu found in urban sites that characterized by traffic density and anthropogenic activities (Onder *et al*, 2007; Sulaiman & Hamzah, 2018; Kuklová *et al*., 2019). Another possible explanation for this is may return back to its natural availability as a minor trace metal in leaves (Celik *et al*., 2005; Burkhead *et al*., 2009; Aguirre & Pilon, 2016). In fact, copper is an essential element in higher plants, 70% of the available Cu is within the plant's chloroplast as it's a cofactor for Plastocyanin (Aguirre & Pilon, 2016; Burkhead *et al*., 2009).

Previously, the top roadside soils also are strong bioindicators of heavy metal pollution as a result of metal emission from vehicle exhaust and settle on roadside soil (Markus & McBratney, 1996; Wilcke *et al*., 1998; Christoforidis & Stamatis, 2009; Devi *et al*., 2015). Furthermore, road wear is critical for airborne particles release from road traffic (Gustafsson, 2018). The key heavy metals Zn, Cu and Cd are resulted from tire abrasion, car components, lubricants, industrial and incinerator emissions, as well as from tear and wear of vehicles (Wilcke *et al*., 1998; Christoforidis & Stamatis, 2009; Devi *et al*., 2015). While in case of Pb the main source of it is high levels is the leaded gasoline (Christoforidis & Stamatis, 2009). In the current study, the value of Pb in plant leaves is higher than soil (Figure 1a &2a) this may be explained by the fact that uptake from soil elevate the foliar Pb concentration (Motto *et al*., 1970). Another possible explanation for this results is the uptake of lead by root system has been recorded in the greenhouse, while in the field experiments most uptake was demonstrated to be through the shoot system (Motto *et al*., 1970). Besides in a particulate form up to 75% of Pb is emitted from the exhausts of motor vehicles (Huntzicker *et al*., 1974; Ndiokwere, 1984). By way of illustration, the obtained results of HW found to be above the safe limits and higher than the result found in other countries according to study performed by (Farid, 2015; Ndiokwere, 1984; Onder *et al*., 2007).

For cadmium concentration in soil samples, the result ranged between 0.6 and 5.64 ppm for the determined urban areas, while for control sites between 0.22 and 1.14 ppm. The concentration of Cd in urban soils in all the sites exceed their background value, and the highest mean is found in CC. The achieved data are considered toxic and highly risky, compared with the acceptable rate of Cd in soil (0.1 ppm) determined by (Alloway, 1995; Cicek & Koparal, 2004; Onder *et al*., 2007). In comparison with the previous study, the rate of Cd is dramatically high in the present study (Onder *et al*., 2007; Janger, 2012; Farid, 2015) from the obtained results the rate of Cd in CC was higher than HW, the finding is consistent with(Khan *et al*., 2011) which concluded that the traffic density had a small effect on the Cd concentrations in the roadside soils.

The level of Cu in HW range between 33.64 and 81.14 ppm, in CC from 55.44 to 78.87 ppm, in Purb between 34.02 and 54.81 ppm, while for control area ranges within 12.62 and 21.61 ppm. The concentration of Cu in Purb and Control were high but still within the permissible range 24-55 $mg.kg^{-1}$ (Alloway, 1995). While, in CC and some location of HW shown elevated concentrations, above the safe range. The high levels of Cu maybe return to the nature of the soil. The reason of the copper existence in all the rocks of the earth's crust with contents differ according to the rock nature. In general, the overall Cu content in various type of soils start from traces and reach 200–250 ppm; while the average starts from 15 up to 40 ppm (Aubert & Pinta, 1977). The effect of the parent rock on the soil's copper content in total is particularly obvious (Aubert & Pinta, 1977).

CONCLUSION

The findings of this study have a number of important implications for future practices. According to the revealed results, the Pine is an effective bioaccumulator for urban areas. Moreover, the present finding also supports previous studies which concluded that the coniferous trees are more useful in accumulation of particulate matter (PM) than broad-leaved trees (Beckett *et al*., 1998; Sæbø *et al*., 2012; Alahabadi *et al*., 2017; Albeyboni, Submitted 2019). Nevertheless, the coniferous tree species are often not recommended for roadside plantings (Dzierżanowski *et al*., 2011).

Currently, the urban green space increasingly became an essential part of urban planning and design especially with respect to roadside planning and management.

The evidence of this study suggests that more researches are necessary for better understanding the role of urban greening as bioaccumulators in Duhok City due to the seriousness of air pollution problems and the tree effective role in mitigating the hazardous consequences. Moreover, further experimental investigations are highly needed to evaluate the capacity of other urban tree species especially the native ones within urban environments.

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Table (1);- The value of heavy metals in *P. brutia* tree leaves and in soil

			Pb		Cd		Cu	
Site	Latitude	Longitude	leaves	Soil	Leaves	soil	leaves	soil
Highway 1 (HW1)	N36 50' 48.390"	E43 01' 47.26"	58.21	99.62	3.66	1.41	6.37	33.64
Highway 2 (HW2)	N36 50' 51.38"	E43 0' 56.79"	120.75	99.98	9.01	4.52	15.12	55.94
Highway 3 (HW3)	N36 50' 45.605"	E042 59' 05.535"	12.13	80.35	1.58	2.54	10.96	81.14
Highway 4 (HW4)	N36 51' 30.97"	E042 58' 35.52"	11.83	89.04	1.41	1.52	31.37	54.43
Highway 5 (HW5)	N36 51' 18.754"	E042 57' 06.320"	11.55	55.14	1.34	0.6	32.76	40.57
Highway 6 (HW6)	N36 51' 22.90"	E042 56' 11.01"	8.29	64.36	0.97	1.17	15.37	59.72
Highway 7 (HW7)	N36 51' 03.359"	E 042 57' 37.246"	72.38	99.89	6.97	1.49	11.34	44.6
Peri-urban 1 (PU1)	N36 52' 48.69"	E042 56' 07.268"	12.71	11.96	0.88	3.2	18.65	54.81
Peri-urban 2 (PU2)	N36 50' 41.084"	E 043 00' 15.90"	12.26	8.72	0.84	1.28	10.46	34.02
Peri-urban 3 (PU3)	N36 52'42. 305"	E042 57' 16.784"	2.94	4.07	1.57	1.24	30.31	45.23
Peri-urban 4 (PU4)	N36 50' 44.078"	E042 59' 40.746"	7.02	4.65	2.12	1.17	29.18	36.7
City Center 1 (CC1)	N36 51' 44.338"	E042 59' 44.276"	11.25	48.28	1.24	1.48	8.44	55.94
City Center 2 (CC2)	N36 51' 49.529"	E042 59' 48.217"	73.43	18.45	4.86	5.64	20.79	78.87
City Center 3 (CC3)	N36 51' 58.689"	E042 59' 41.529"	46.1	14.85	3.9	1.46	8.44	55.44
Control 1 (CL1)	N36 53' 52.864"	E43 8' 50.763"	5.01	6.33	0.46	0.40	6.05	12.62
Control 2 (CL2)	N37 00' 06.248"	E043 13' 00.263"	3.25	5.49	0.26	0.22	5.19	21.61
Control 3 (CL3)	N36 52' 19"	E43 7' 34.05"	4.98	4.33	0.56	1.14	5.99	12.89

Table (2):- The average of Heavy metals in Pinus brutia leaves and soil at different site categories

Site categories	Pb		Cd		Cu	
	Pinus	Soil	Pinus	Soil	Pinus	Soil
Control (CL)	4.42	6.66	0.43	0.86	5.74	20.54
Puri-urban (PU)	8.74	7.36	1.36	1.73	22.15	42.69
City Center (CC)	43.60	27.20	3.36	2.86	12.56	63.42
Highway (HW)	42.17	84.06	3.57	1.90	16.62	52.86

Table (3): approximate concentrations of Trace elements in mature leaf tissue generalized for various species (Kabata-Pendias & Pendias, 2001)

Element	Deficient (if less than the stated amounts of essential elements)	Sufficient or normal	Excessive or Toxic	Tolerable in Agronomic Crops
Pb	-	5-10	30-300	0.5-10
Cd	-	0.05-0.2	5-30	0.05-0.5
Cu	2-5	5-30	20-100	5-20

Table (4): WHO permissible limits of heavy metals in soil

Elements	Target value of soil ($mg.kg^{-1}$)
Pb	85
Cd	0.8
Cu	36

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Fig. (1a): concentration of Pb rate in leaves of *P. brutia* in both urban and natural area (Highway, City Center, Peri-urban and Control area)

The letter a, and b, indicate the different between the categories according to Student-Newman-Keuls (SNK) test

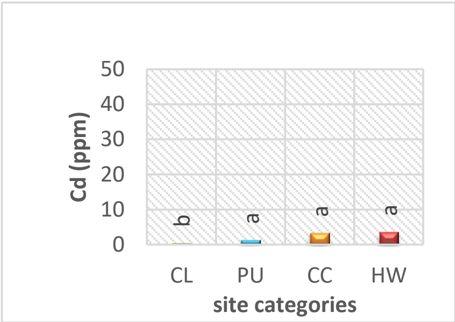

Fig. (1b): Concentration of Cd rate in leaves of *P. brutia* in both urban and natural area (Highway, City Center, Peri-urban and Control area)

The letter a and b indicate the differences between the categories according to Student-Newman-Keuls (SNK) test

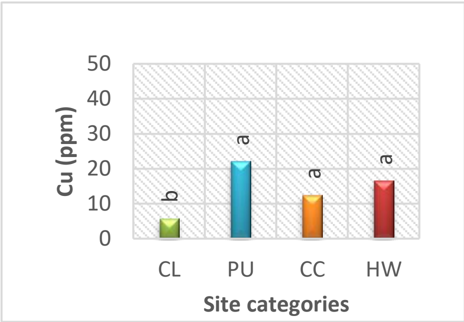

Fig. (1C): Concentration of Cu rate in leaves of *P. brutia* in both urban and natural area (Highway, City Center, Peri-urban and Control area)

The letter a and b indicate the differences between the categories according to Student-Newman-Keuls (SNK) test

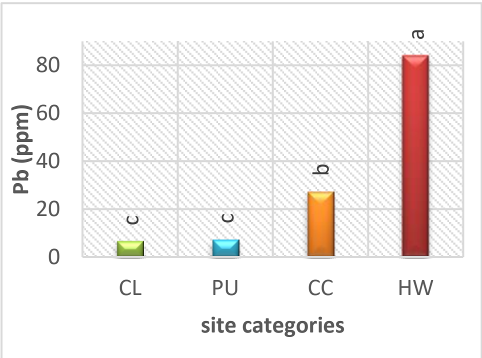

Fig. (2 a): concentration of Pb rate in soil in both urban and natural area (Highway, City Center, Peri-urban and Control area)

The letter b and c indicate the different between the categories according to Student-Newman-Keuls (SNK) test

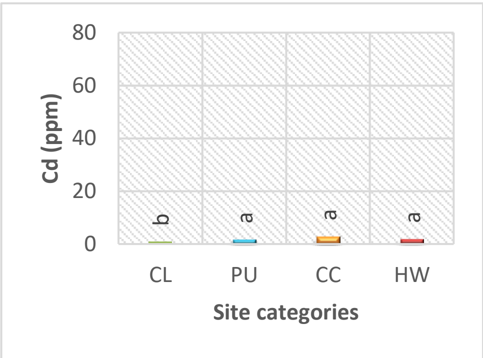

Fig. (2 b): concentration of Cd rate in soil in both urban and natural area (Highway, City Center, Peri-urban and Control area)

The letter a and b indicate the different between the categories according to Student-Newman-Keuls (SNK) test

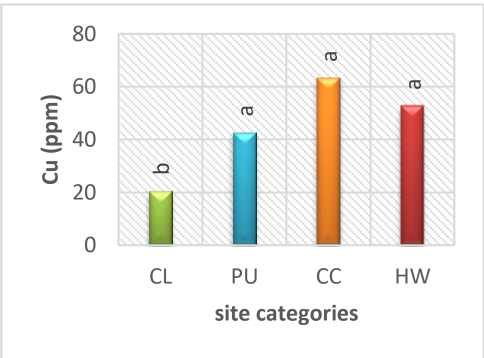

Fig. (2 c): concentration of Cu rate in soil in both urban and natural area (Highway, City Center, Peri-urban and Control area)

The letter b and a indicate the different between the categories according to Student-Newman-Keuls (SNK) test

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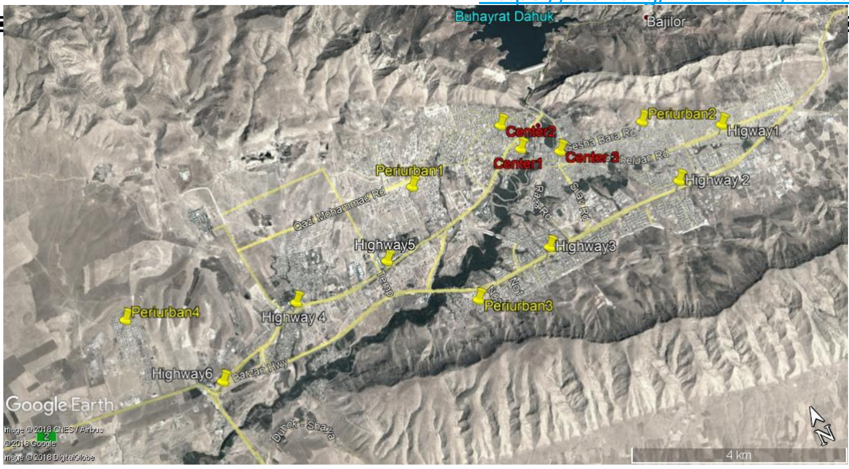

Fig. (3) : location of taken samples from different locations

ڤەكۆلینا كومبوونا كانزاییێن قورس د دارا كاژێ دا ل جهێن شارستانی ل پارێزگەها دهوك, هەرێما كوردستانێ, عێراق

پوخته :

شارستانی یا هەڤچەرخا جیهانێ گەلەك هەڤركیێن ژینگەهی پەیدا دكەت كو كاریگەرییێن دژوار ل سەر تەندروستیا مرۆڤی هەنە, بو نموونە: دەركرنا وان ماددێن د بنە ئەگەرێ پیس بوونا هەوای. ل ڤان روژان دا ل هەرێما كوردستانێ پرانیا باژێران د پێژڤەچوونەكا شارستانیا ب لەز دانە, ب ڤی رەنگی, د ئەنجام دا كاریگەریێ ل كوالێتیا ژینگەها شارستانی دكەت ب رێكا بلند بوونا ئاستێ پیس بوونا هەوای. سەرەرای ڤێ چەندێ, هەردوو جڤاكێن زانستی و سیاسیێن خودان بریار سەرنجەكا كێم هەیە ل دور رولێ داروباران ل سەر كانزاییێن قورس كو نیشاندەرێن بایولوجی نە یێن پیس بوونا هەوای. ژ بەر وێ یەكێ, ئارمانجا سەرەكی د ڤێ ڤەكولینێ دا هەلسەنگاندنەكە بو كانزاییێن قورس كو ب چ رەنگ بەلاڤ بووینە د ناڤ جهێن شارستانیێن جیاواز دا, هەروەسا دوپاتكرنا رولێ گرنگێ دارستانێن باژێری یە ل سەر باشكرنا تەندروستیا مروڤان ل پارێزگەها دهوكێ. چەند كانزاییێن قورس (قورقوشم, كادمیۆم و مس) هاتنە هەلسەنگاندن, كوم ببون ب رێكا بەلگێن داروبارێن (كاژاێن) باژێری ئەوێن ل زور جهان شین بوین یان هاتینە چاندن. جه هاتنە دەستنیشانكرن ل گور ڤان چینا: سەنتەرێ باژێری, رێكێن گشتی, جهێن نیڤ شارستانی و دەڤەرێن سروشتی. بو دیاریكرنا كوومكرنا كانزاییێن قورس دناڤ ئاخێ و بەلگان دا پروتوكولا (مارتن و لیندزی, 1990) هاتە ب كارئینان. ئەنجامێن مە هاتنە دیاركرن كو دارا كاژێ یا سەركەفتی یە بو كومكرنا كانزاییێن قورس ل دەڤەرێن شارستانی یێن دهوكێ. سەرەرای ڤێ چەندێ ژی, بەلگێن دارا پتر ژ ئاخێ كانزاییێن قورس كوم د كەن و بخو د كێشن. هەروەسا هاتە دیاركرن كو ئاستێن بلند یێن كانزاییێن قورس د ناڤ ئاخێ و بەلگێن دارا دا ل جهێن زێدە شارستانییەت و قەرەباڵغ هەنە. تشتێ هەرە بالكێش, كانزاییێن قورس ئەوێن هاتینە ڤەكولین د ناڤا جۆرێن دارا و ئاخێ دا, رێژەیا وان ل سەر مەودایێن باش (نە د رێژێن نورمال) دا بوون ل زوربەی جهێن شارستانی, ب تایبەت ل سەر رێكێن سەرەكی و سەنتەرێ باژێری دا. د ڤێ مژارێ دا, جهێن كەسك ب گشتی, و هێلێن كەسكاتیێ ب تایبەتی, د بنە پارچێن پێتفی د هەر جورە دیزاینەكا شارستانی دا. هەرچاوا بیت, خاندن و ڤەكولینێن زێدەتر دڤێت بهێنە ئەنجام دان بو دیاركرنا كاریگەرییێن جورێن دی یێن داروبارا وەك كومكەرێن كانزاییێن قورس داكو بهێنە دابینكرن ل جهێن باژێر لێ دهێنە ئاڤاكرن بو كومكرن و گرتنا كانزاییێن قورس و كێم كرنا ئاستێ پیس بوونا هەوای ل باژێرێ دهوكێ.

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قياس التراكم الحيوي للعناصر الثقيلة قي أوراق شجرة الصنوبر في محافظة دهوك – أقليم كردستان العراق

الخلاصة

المدن المعاصرة لها تداعياتها في خلق مشاكل و أزمات ومن أهمها التلوث البيئي واللذي بدوره يأثر بشكل سلبي على صحة المواطن و سلامته مثل التلوث الناجم عن عوادم ألسيارات. حالياَ, إن التطور العمراني الملحوظ والسريع لمعظم مدن إقليم كوردستان بدأ يؤثر بشكل سلبي على نوعية الهواء بسبب زيادة نسبة تلوث. مما زاد من هذه النسبة, قلة اللأهتمام بالتشجير في المدن من قبل الجهات المختصة العلمية منها و الأدارية. الهدف الرئيسي من هذا البحث هو معرفة كيفية انتشار و تركيز العناصر الثقيلة في مختلف المناطق السكنية و كذلك التركيز على مدى أهمية تشجير المدن من أجل تحسين حياة و صحة المواطنين في محافظة دهوك بشكل خاص و في باقي المحافظات بشكل عام. يُقيم البحث الحالي كمية تراكم بعض العناصر الثقيلة التي تم إختيارها (رصاص و كادميوم و نحاس) على أوراق أشجار الصنوبر. حيث تم اخذ عينات عشوائية من أوراق أشجارالصنوبر و التربة من مناطق مختلفة. و بخصوص الأماكن التي تم اخذ العينات منها هي: وسط المدينة, الشوارع الرئيسية, أطراف المدينة, و المناطق الطبيعية. تم الاعتماد على بروتوكول (مارتينز و ليندزي, 1990) لتحديد كمية تراكم العناصر الثقيلة في التربة و الأوراق. لقد بينت نتائج الفحوصات و البحث أن شجرة الصنوبر هي من الأشجار الناجحة و المعتمدة لامتصاص العناصر الثقيلة في مناطق محافظة دهوك. واحدة من النقاط الجديرة بالذكر التي لوحظت خلال البحث هي أن أوراق الأشجار لها قابيلة أكبر و أكثر في امتصاص و تراكم العناصر الثقيلة مقارنة بالتربة. علاوة على ذلك, أشارت عينات أوراق أشجار الصنوبر و التربة في المناطق المزدحمة الى نسب عالية من العناصر الثقيلة الممتصة مقارنة مع المناطق الأخرى ذات الكثافة الأقل نسبياً. و من المثير للأهتمام, دلت العناصر الثقيلة التي تم اختيارها في هذا البحث من مختلف أنواع الاشجار و التربة على نسب عالية جدا و التي تعتبر فوق خط الآمن في معظم مناطق المحافظة و بالأخص في وسط المدينة و الشوارع الرئيسية. في هذا الصدد, يجب الأخذ بعين الاعتبار المسطحات الخضراء بشكل عام و الحزام الأخضر بشكل خاص من العوامل الرئيسية و المهمة في أي مشروع تشجير مدني. في النهاية, يتطلب اجراء المزيد من البحوث و الدراسات الاضافية لتبين مدى أهمية و فعالية الاشجار الأخرى في امتصاص العناصر الثقيلة. و ذلك من أجل زراعة و غرس هذه الاشجار في المناطق ذات نسب عالية من العناصر الثقيلة لأمتصاصها و تقليل نسبة تلوث الهواء في محافظة دهوك.