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Evaluation of Pollution Intensity in Different Districts of Tehran Based on Measuring Chlorophyll, Plumb and Cadmium Heavy Metal Contents in Trees

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ABSTRACT: Plane and Mulberry trees play a crucial role in purifying the polluted air in Tehran as a major city. In this research, 13 main districts of Tehran city were chosen as study area. 20 completely healthy Plane and Mulberry species were selected in similar ecological conditions and age range. The uptake of Cd and Pb was determined using Spectrophotometry, whereas the Chlorophyll content was measured applying ICP method. The statistical results of Chlorophyll data put the Mulberry and Plane trees of the studied district into 9 classes (Dunkan statistical test). The statistical results put the studied districts in terms of amount of Pb uptake in 3 classes for Plane trees and in 5 classes for Mulberry trees. The districts were classified in 5 classes for plane trees and in 4 classes for Mulberry trees in terms of amount of Cd uptake. In general, the uptake content of Cd and Pb is higher in Plane trees in comparison with Mulberry ones. In other words, Plane trees are more sensitive to the uptake of contaminants than Mulberry trees. Finally, GIS maps were designed showing the average uptake of contaminates in each district.

Key words: Plane tree, Mulberry tree, Phytoremediation, Tehran, Contaminants

INTRODUCTION

In recent years, pollution in major cities such as Tehran is considered as the fundamental infrastructural problems of governments. The main reason for an increase in pollution is, in fact, an unusual population growth. The population of Tehran has increased from 1512 000 in 1956 to 8244 535 in 2011. Several researches prove the role of plants specially trees as air, water and soil purifiers of contaminants. Phytoremediation is a strategy of reducing pollution in the environment in which plants, roots and microbial colonies may result in the absorption and elimination of contaminants from soil and water and transformation of them to the plant tissues (Robinson *et al.*, 2003).

Life on the earth depends on the solar energy. Photosynthesis is the only important biological process through which plants can use this energy source directly. In addition, a huge amount of energy sources on the planet earth originate from the photosynthetic processes done at present or in the past. The most active photosynthetic tissue in vascular plants is mesophyll in leaves. Mesophyll cells bear abundant number of Chloroplasts. Chloroplasts contain chlorophylls. Cells in leaves have the maximum number of Chloroplasts and therefore, are considered as the main photosynthetic tissues in plants (Lawson& *et al.*, 2002). According to their long life span, trees could be a suitable indicator to determine the trends of pollution alterations where they are established. Plane (*Platanus orientalis*) and Mulberry (*Morus alba*) trees are the best indicators of the identification of the environmental changes such as evaluation of the content of contaminants (Phytoremediation), as they are planted in a wide scale in Tehran city (Korori *et al.*, 2010).

Plants and green algae contain a and b Chlorophylls. Some other plant pigments such as

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phycoerythrin and phycocyanin play a slight role in Photosynthesis (Dos Santos, A. *et al.,* 2003). The results of some of the researches indicated that accumulation of some heavy metals such as Cd and Pb is high in leaves, especially in broad ones, because these elements may damage chloroplasts in young leaves and cause photosynthesis to decline (Andersson & Bingefors, 1985). Moreover, it has been proved that a decrease in the growth of plants under tension conditions is due to the restriction of Photosynthetic process (Ackerson & Herberst, 1981). Studies also showed that the first impact of Cd on plants is the reduction of Photosynthesis (Fischer *et al.*, 1985, Karataglis *et al.*, 1991). Mehne-Jakobs (1996) investigated the effect of lack of Mg in reducing photosynthesis in Noel pines and found that the absorption rate of CO2 in a one year-old needle leaves declined meaningfully after a 6-month-treatment of Mg in these trees. However, no change was observed in Chlorophyll concentrations in intact treatments. In other words, Mg has had an impact on the Carboxylation mechanism. In a research done by Arduini et al. (1998), seeds of ash tree (*Fraxinus angustifolia)* collected from San Rossore National Park in Italy, were exposed to the different concentrations of Cd and Cu in a hydroponic environment for about 6 months. This study demonstrated that an increase in Cu and Cd content, biomass root and areal tissues of Ash tree decreased and chlorosis occurred in leaves exposed to Cd. Ultimately, Chlorosis was taken as an indicator of toxicity of heavy metals in plants (Arduini *et al.,* 1998).Takagi & Gyokusen (2004), appraised the impact of light and pollution on the photosynthesis of trees planted on the streets in urban area. The results of this research revealed that the rate of photosynthesis is the highest and the lowest in the city center and suburbs, respectively. The important point in this study is, there was a negative correlation between the rate of Photosynthesis and light condition, whereas there is a positive correlation between the rate of photosynthesis and concentration of air contaminants.

In a study conducted in Istanbul Turkey, Baycu et al. (2006), found that the maximum content of Ni and Pb were accumulated through the surface uptake in the leaves of ash tree and the tree of heaven (*Ailanthus spp*). Additionally, chlorophyll content in leaves was considered as a suitable indicator of the tension of heavy metals in urban area, since the content of Chlorophyll in a polluted site decrease significantly in comparison with a treatment site. Many researches have been done on the role of trees as indicators of changes in heavy metals, trends of photosynthesis in trees and their alterations in Iran. Cd and Pb are the two important heavy metals of the air contaminants in cities produced and released in the atmosphere through factories, building materials, heavy traffic in cities, fuel and friction of tires as well (Jones, 1999).

The aim of the current research is to study the changes in Chlorophyll content, the uptake content of Pb and Cd as two toxic elements in the leaves of Mulberry (*Morus alba)* and Plane (*Platanus orientals)* trees in 13 main districts of Tehran, which ends in designing GIS maps of the air pollution in Tehran based on the changes in uptake of these elements and physiological discussions.

MATERIALS & METHODS

First 13 districts of Tehran were selected based on the similarity in their ecological conditions and age.(fig.1) Then, environmental phenotypic identity of studied trees was provided. Plane trees were selected so that their DBH range between 34 and 38 cm (in young ages) and they all were healthy phenotypically. These trees were all selected alongside each other due to the nearly stable ecological conditions. Mulberry trees were also healthy phenotypically in a same range of age. The number of Plane and Mulberry trees for any district was determined to be 10 individual stands each. Finally, a total number of 260 individual trees were selected. Sampling was done in the middle of August which is the approximate time for the maximum annual contaminant uptake in the leaves (before occurrence of the autumn season in Tehran). To study the content of Chlorophyll, leaves were sampled from the upper and lower crown and finally 520 combined leaf samples were collected. A and b Chlorophylls were measured using spectrophotometry to evaluate the overall content of Chlorophyll. To measure the Chlorophyll content, 100 mg of fresh leaf was exposed to Acetone solution and increased in volume 5 ml after solving. This solution was centrifuged for 3 minutes and was ready for spectrophotometry measurement. In the end, two formula 1 and 2 were applied to measure the content of Chlorophyll a and b:

(1)Chlorophyll a = (0.0127 * A663) – (0.00269 * A645)

(2)Chlorophyll b = (0.0229 * A645) – (0.00468 * A663)

The results were analyzed using absolutely random blocks methods and Duncan test (Dos Santos & *et al.,* 2003). Pd and Cd were recorded as pbb by ICP after leaf extraction using Digestdahl instrument. After the analysis of uptake content of elements in each individual tree in any district, the average of uptake of these two heavy metals were determined in 13 districts and ultimate analysis of the results was implemented using Games Howell method. Finally, 7 GIS maps were

designed based on the changes in Chlorophyll content and the content of uptake of Cd and Pb elements by the leaves of Mulberry and plane trees in each district.

RESULTS & DISCUSSION

The results have shown based on the ultimate analysis using Duncan test and Games Howell method in fig. 2-4. It should be mentioned that the important point in sampling of the two districts Abdul Abad and Azadi is that the trees in these districts lost their leaves before the falling season and new leaves occurred on these individual stands. In fact, the leaves of the trees in these districts are about two months younger than other districts. Fig. 2 shows the results of Chlorophyll content and Figs 3 and 4 reflect the changes in pb, Cd in the leaf samples taken from the Mulberry and Plane tree in 13 studied districts. Fig. 2 especially reveals that the same alterations were observed due to comparison of the chlorophyll content measurement in upper layer atmosphere of Tehran (crown of Plane trees) and lower layer atmosphere of Tehran (crown of Mulberry trees).

Changes in Chlorophyll content of the studied area fall into 9 classes. The maximum content of Chlorophyll in Plane trees determined to be in Abdulabad (Classes ab - one of the exceptions districts), Jannat Abad (classes bc) and the minimum Content was recorded in Baharestan districts (Class fg). The minimum content of Chlorophyll in mulberry tree was in Khavaran (class gh) and the maximum content was observed in Azadi and Abdul Abad (Classes bc and b respectively - two exceptions districts) and Jannat Abad (class bcde).

Fig. 3, has classified the studied districts in terms of Pb uptake in the leaves of Plane and Mulberry trees based on the statistical analysis in 3 and 5 classes, respectively. The maximum uptake of Pb in Plane trees was observed in Naarmak and Khavaran districts, whereas the minimum uptake of pb in these trees was recorded in Yaft Abad district. The maximum uptake of Pb in Mulberry trees was observed in Mosalla and the minimum uptake occurred in Bolvar-e Keshavarz, Ekbatan and Yaft Abad. Fig. 4 illustrates the statistical results of the studied districts of Plane and Mulberry trees in terms of Cd uptake in 5 and 4 classes, respectively. According to the Figure, the maximum uptake of Cd in the leaves of Plane tree it was observed in terminal-e-Jonoub and Afsarieh and the minimum uptake was observed in Yaft Abad district. In case of Mulberry tree, the maximum uptake of heavy metals Cd occurred in Khavaran and Terminal-e-Jonoub and the minimum uptake was observed in Bolvar-e-Keshavarz, Ekbatan and Yaft Abad districts. Plane trees showed a higher

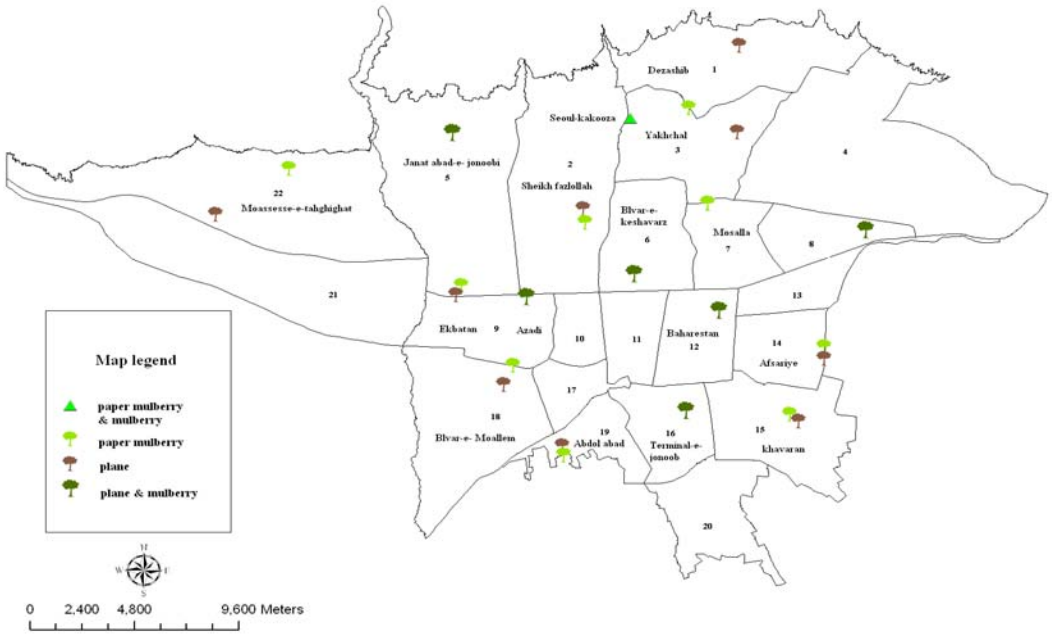

Fig.1. Map of studied districts of Tehran

sensitivity in comparison with Mulberry trees by uptake of 578 302.9 ppb of Pb and 18 225.6 ppb of Cd. 7 GIS maps were provided showing the chlorophyll content of the two tree species analyzed in the studied districts.

Nowak 1995 reported that urban plant cover affects the surroundings weather directly and indirectly and the intensity of the effect is higher in city centers and highly populated area. Several studies revealed that an increase in Photosynthesis process is due to the environmental tension, especially an increase in contaminants (Karataglis *et al.*, 1991; Matsushima *et al.*, 2006; Baycu *et al.*, 2009). The results of these researches correspond to findings of the current study. However, there are two exceptions about Azadi and Abdol Abad districts which the chlorophyll content increases due to higher amount of contaminations. There might be two possible reasons for these exceptions: either the higher sensitivity of trees to the contaminants or the pollution content might be higher in these districts. Since, two different species were sampled for any district (10 individual stands in each district), the second one could be more likely to accept. The sediments of heavy metals in the soil, affects many parameters related to the growth and development of plants such as metabolic interactions (Baycu *et al.*, 2006). The results f some other researches demonstrated that accumulation of some heavy metals such as Pb and Cd in leaves may cause the Chloroplasts in young leaves to damage and , finally result in a decrease in photosynthesis (Andersson & Bingefors , 1985). Some similar researches revealed that the first impact of Cd on plant is a decline in Photosynthesis (Fisher *et al.*, 1985; Karataglis S *et al.*, 1991). Arduini et al. (1998) proved that an increase in the content of contaminants is positively correlated with an increase in Photosynthesis. If the content of contamination is higher than a certain amount, the amount of Photosynthesis reduces and ultimately, a higher content of contamination might end to the death of the plant.

The role of trees as indicator of ecosystem changes has been proved in several researches. In studies done on the Oak (*Quercus brantii var.persica),* Mangrove (*Avicennia marina),* Cashaw (*Prosopis cineraria)* and Chris-thorn (*Ziziphus spina-christi),* the impacts of Persian Gulf War (between Iraq and Kuwait in 1991) on the various organisms of southern and central regions of Iran was investigated 7 years after the occurrence of the war. Then the intensity of disturbance of natural ecosystems and the time needed for the rehabilitation was determined (Korori *et al.*, 2011). The researches proved that the higher the contamination, the higher energy is consumed by plants which lead to a higher photosynthesis, so the chlorophyll content would decrease (Andersson & Bingefors, 1985). The results obtained from the recent research have proved this as well. For instance, a decrease in chlorophyll content was observed in Naarmak, Khavaran and Sheikh Fazl-ul-lah (the districts where has the higher content of contamination), whereas a reverse result was observed in Jannat Abad, Yaft Abad and Ekbatan. In addition, the research done by Korori et al. (2010) demonstrated that the uptake of Pb and Cd content through the trunk of the trees (1.3 m DBH) increased considerably in districts where construction and development has been implemented in a high level during the recent decade such as district 2 and 3 in Tehran.

In the recent study, an increase in Cd and Pb content resulted in decreasing Chlorophyll content in Both Mulberry and plane trees. In districts Naarmak, Khavara n and Terminal-e-Jonoub, the maximum uptake of Cd and Pb occurred and caused the Chlorophyll content to decrease. This is due to the higher photosynthesis intensity in trees. These districts are located at the center of Tehran with a high traffic intensity of trucks. The results of this research correspond to the results obtained from Novak and Matsushima et al studies. Interestingly, the Chlorophyll content has decreased in all districts where the uptake of Cd and Pb is higher, except for the Azadi and Abdul Abad districts (where the fall of the leaves in Summer and emergence of new leaves on trees occurred).This result corresponds to the results of other researchers such as Desmond (1992). About these two exception districts (Abdol Abad and Azadi) which sampling was at the same time with the other districts, but they do not have shown the maximum amount of contamination. It should be mentioned that it is because the fact that the trees in these districts lost their leaves before the falling season and new leaves occurred on these individual stands. In fact, the leaves of the trees in these districts are about two months younger than other districts. The reason is either the higher amount of contamination in these districts rather than the others or the higher sensitivity of these trees to the beginning of hot season. However, the researchers believed that the first reason is more acceptable.

In 7 following GIS maps (Figs. 5-11), an increase in the content of Pb and Cd and pollution alteration (decrease in Chlorophyll content) is determined by changing in colors. This method is implemented by other researchers as well (Der Lin & Chang Lin, 2002; Puliafito& *et al.*, 2002).). In the two exception districts, based on the achieved results and the complementary visit, we can confess that the amount of contamination should be higher than the other districts.

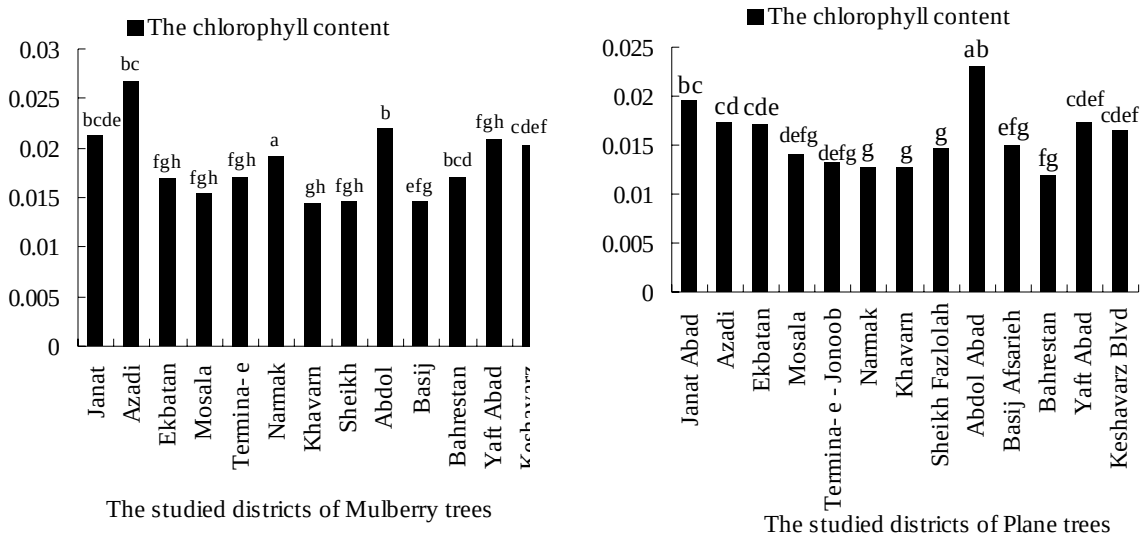

Fig. 2. Comparison of the average of the Chlorophyll content measurement in Plane and Mulberry trees in the studied districts

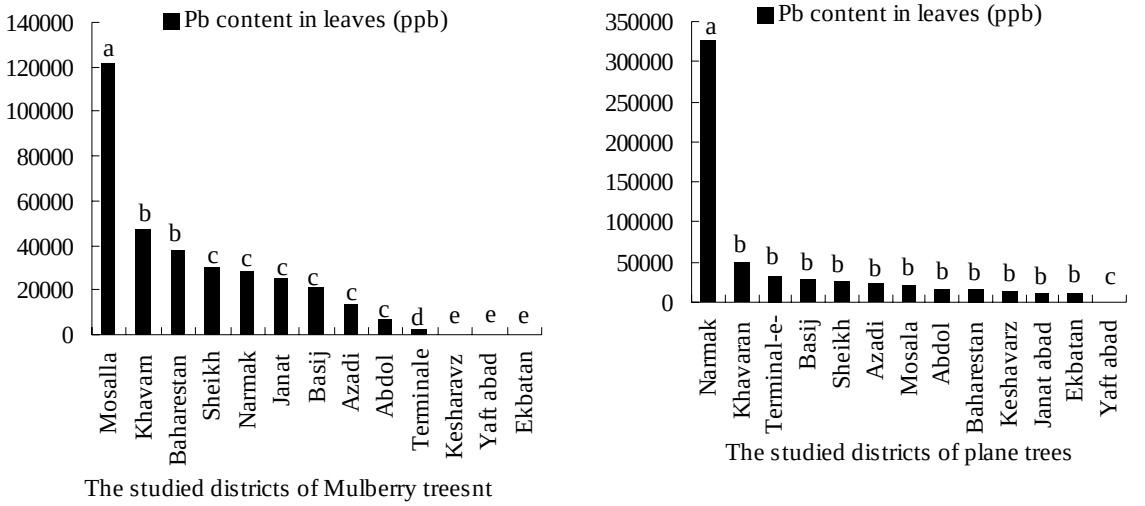

Fig. 3.Comparison of the average of the Pb content measurement in Plane and Mulberry trees in the studied districts

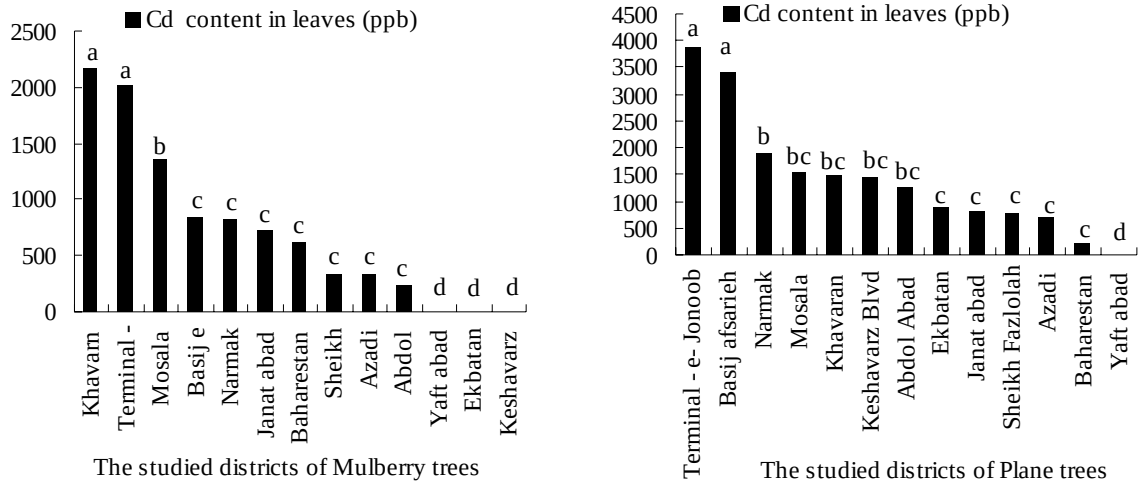

Fig.4.Comparison of the average of the Cd content measurement in Plane and Mulberry trees in the studied districts

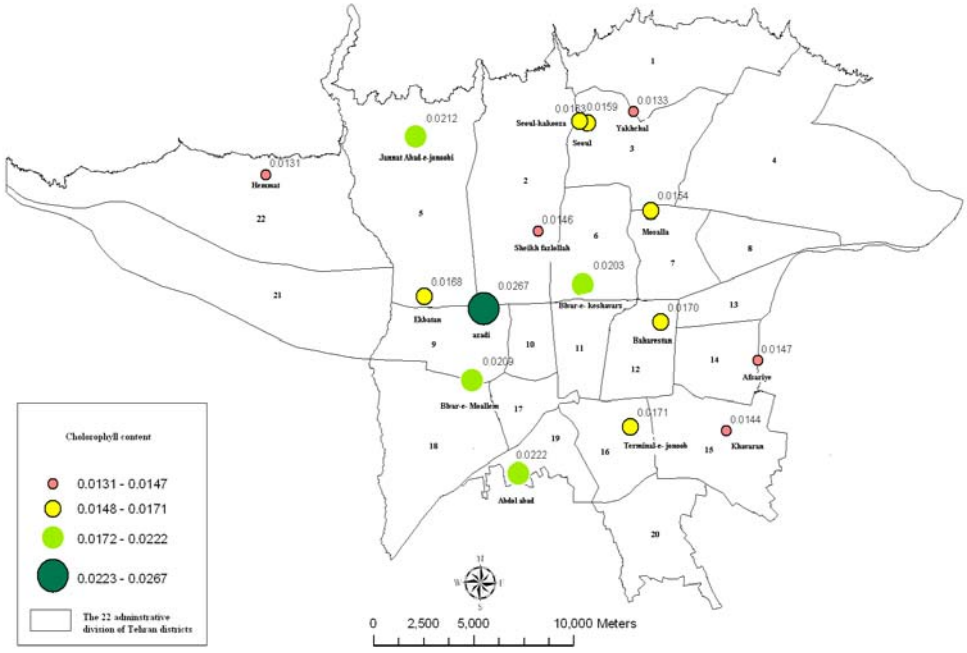

Fig. 5. .Map of Pollution in Tehran based on the analysis of chlorophyll content in Mulberry trees

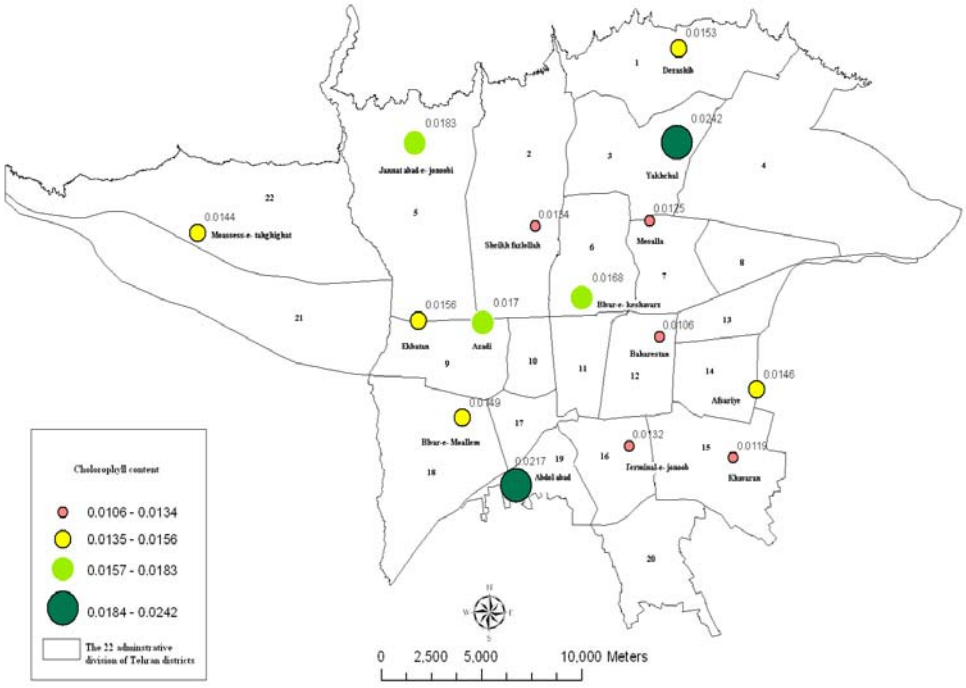

Fig. 6. Map of Pollution in Tehran based on the analysis of chlorophyll content in the upper leaves of Plane trees

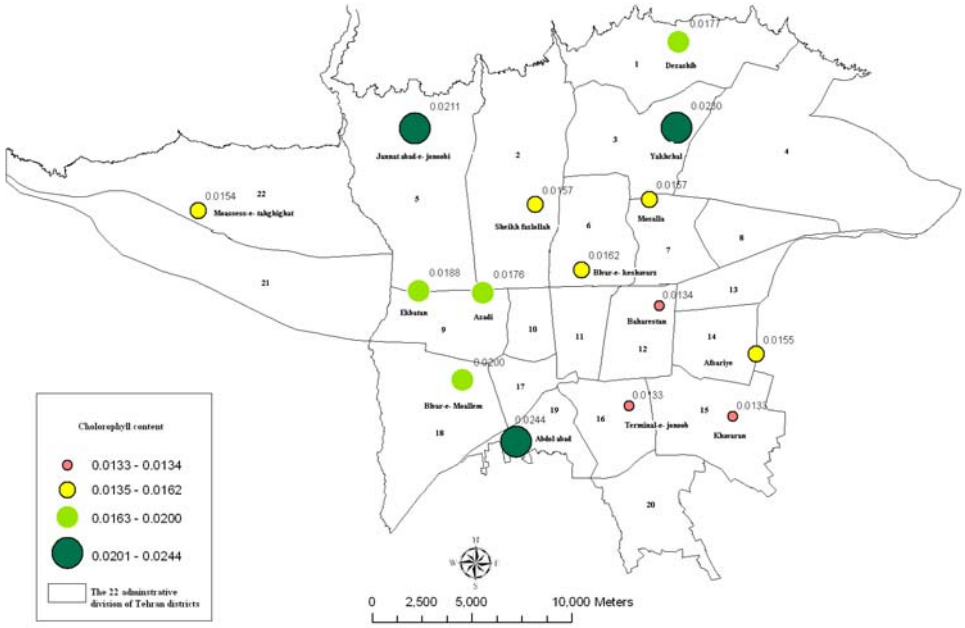

Fig. 7. Map of Pollution in Tehran based on the analysis of chlorophyll content in the lower leaves of Plane trees

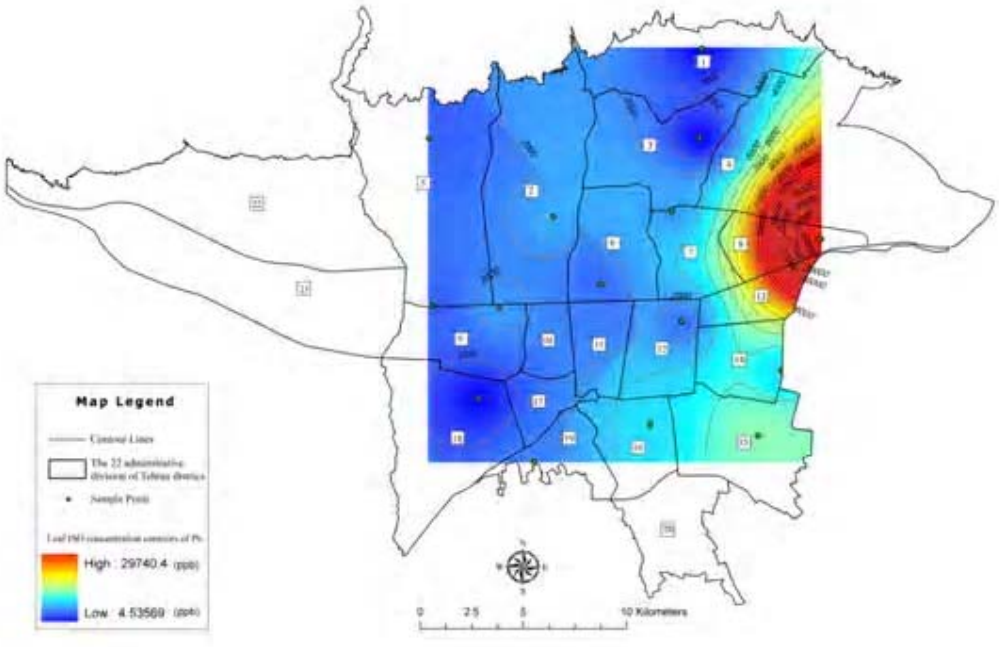

Fig. 8. The average concentration of Pb in the leaves of Plane trees in the studied districts

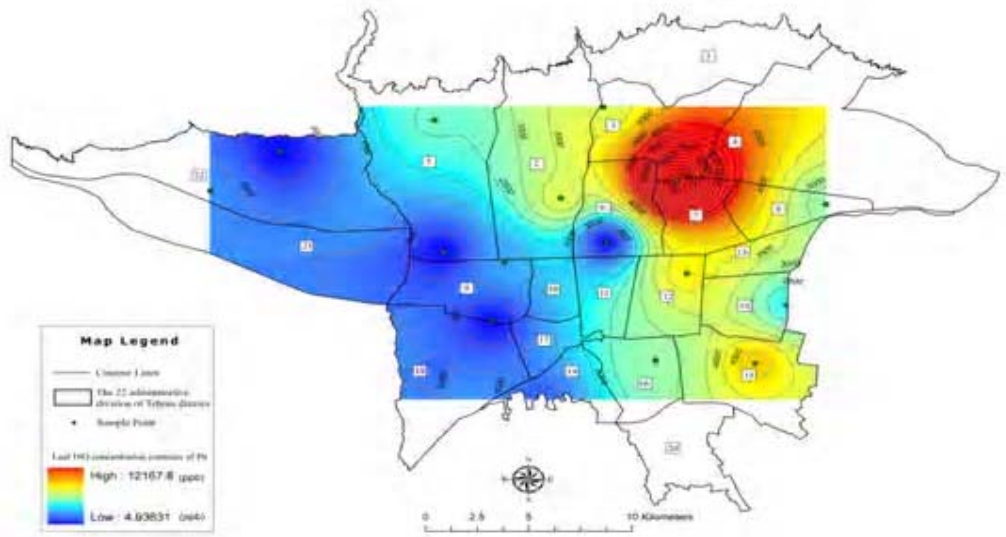

Fig. 9. The average concentration of Pb in the leaves of Mulberry trees in the studied districts

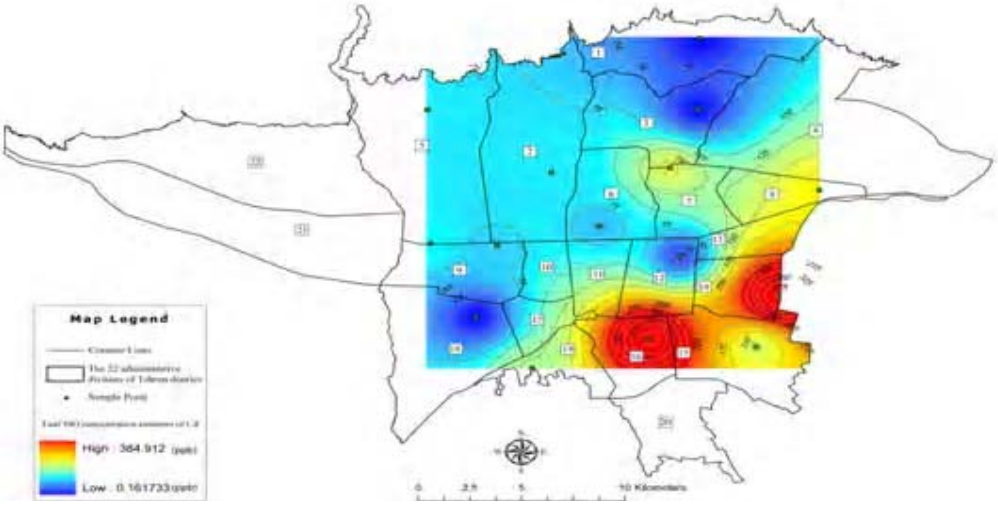

Fig. 10. The average concentration of Cd in the leaves of Plane trees in the studied districts

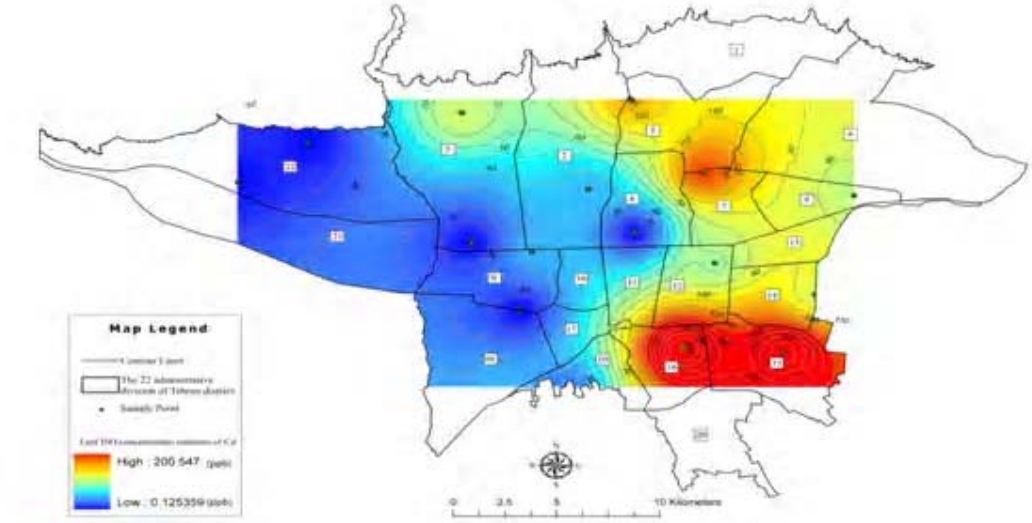

Fig. 11. The average concentration of Cd in the leaves of Mulberry trees in the studied districts

CONCLUSION

This research proves that trees can be used as a precise indicator to evaluation the amount of contamination. The results of this study demonstrated that the storage content of Pb and Cd in the leaves of plane tree (the average height of 18 meter) is generally higher than the leaves of Mulberry tree (the average height of 5 meter). There might be two reasons for this: either the pollution content of Tehran might be higher in higher altitudes (which is not in harmony with the special weight of contaminants, because the accumulation of heavy metals occurs in lower altitudes) or the sensitivity of plane trees to the contaminants is higher in comparison to that of Mulberry trees (which is scientifically approved). Other researchers proved that several species and intra specific species have shown different sensitivities to the environmental tensions (Unterbrunner & *et al.*, 2007; Suarez, *et al.*, 2009). It should be noticed that in urban tree planting, the aesthetic aspects of trees and the ability of uptake the pollutants both are important. In general, Khavaran district was introduced as the most pollutant studied district in his research. A large population of Tehran live in this area and many diesel trucks pass through it. The recent results showed that the storage content of Pb and Cd in Tehran higher than Pathogenic limit and near the pathogenic limit, respectively (USEPA). In addition to Mulberry and Plane trees, various plants have been planted in different strata which are able to store the heavy metals based on the species and probably intraspecific species abilities. In 7 developed GIS maps, an increase in the content of Pb and Cd and pollution alteration (decrease in Chlorophyll content) is determined by changing in colors. This method is implemented by other researchers as well (Der Lin & Chang Lin, 2002; Puliafito& *et al.*, 2002).

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REFERENCES

Ackerson, R. C., and Hebert, R. R. (1981). Osmoregulation in cotton in response to water stress. I. Alterations photosynthesis, leaf conductance, translocation and ultra structure. Plant physiology, **67**, 484-488.

Andersson, A. and Bingefors, S. (1985). Trends and annual variations in Cd concentra-tion in grain of winter wheat. Acta Agriculture Scandinavia, **35**, 339-344.

Arduini, I., Godbold, D. L., Onnis, A. and Stefani, A. (1998). Heavy metals influence mineral nutrition of tree seedling, Chemosphere, **36 (4-5)**, 739-747.

Baycu, G., Tolunay, D., Ozden, H. and Gunebakan, S. (2006). Ecophysiological and seasonal variation in Cd, Pb, Zn and Ni concentration in the leaves of urban deciduous trees in Istanbul, Environmental Pollution, **143**, 545-554.

Der Lin, M., and Chang Lin, Y. (2002). The application of GIS to air quality analysis in Taichung City, Taiwan, ROC, Environmental Modeling and Software, **17 (1)**, 11–19.

Desmond, R. L. and Flore, J. A. (1992). Photosynthetic Compensation to Partial Leaf Area Reduction in Sour Cherry, J. AMER. Soc. HORT. SCI., **117 (2)**, 279-286.

Dos Santos, A. C. A., Calijuri, M. C., Moraes, E. M., Adorno, M. A. T., Falco, P. B., Carvalho, D. P., Deberdt, G. L. B. and benassi, S. F. (2003). Comparison of three methods for Chlorophyll determination: Specterophotometry and Fluorimetry in samples containing pigment mixtures and specterophotometry in samples with separate pigments through High Performance Liquid Chromatography. Acta Limonol, Bras, **15 (3)**, 7-18.

Fisher, R. A., Rees, D., Sayre, K. D., Lu, Z. M., Candon, A. G., and Saavedra, A. L. (1998). Wheat yield progress associated with higher stomatal conductance and photosynthetic rate, and cooler canopies. Crop Sci., **38 (6)**, 1467-1475.

Jones, J. B. (1999). Laboratorium Guide for Conducting Soil Tests and Plant Analysis. CRC, New York.

Karataglis, S., Moustakas, M. and Symeonidis, L. (1991). Effects of heavy metals on isoperoxidases of wheat. Biologia Planarumt (Praha); **33**, 3–9.

Korori, S. A. A., Shirvani, A., Khoshnevis. M. and Matinizadeh, M. (2011). Pollution effects of Persian Gulf War on the southern regions of Iran. Jahade Daneshgahi Press, Tarbiat Moalem University, 370p.

Korori, A. A. S., Valipour, K. H., Shabestani, S., shirvany, A. and Matinizadeh, M. (2010). A 25-year Monitoring of the Air Pollution Depicted by Plane Tree Species in Tehran. World Academy of Science Engineering and Technology (WASET), 6 (70).

Lawson, T., Oxborough, K., Morison, J. I. and Baker, N. R. (2002). Responses of Photosynthetic Electron Transport in Stomatal Guard Cells and Mesophyll Cells in Intact Leaves to Light, CO2, and Humidity, Journal of Plant Physiology, **128 (1)**, 52-62.

Matsushima, U., Kardjilov, N., Hilger, A., Manke, I., Shono, H. and Herppich, W. B. (2009). Visualization of water usage and photosynthetic activity of street trees exposed to 2ppm of SO2-A combined evaluation by cold neutron and chlorophyll fluorescence imaging. Nuclear Instruments and Methods in Physics Research Section A: Accelera-tors, Spectrometers, Detectors and Associated Equipment, **605 (1-2)**, 185-187.

Mehne-Jakobs, B. (1996). Magnesium deficiency treatment causes reductions in photosynthesis of well-nourished Norway spruce, **10 (5)**, 293-300.

Nowak, D. J. (1995). Trees pollute? A "TREE" explains it all. In: Proceedings of the 7th National Urban Forestry Conference. Washington, DC: American Forests, pp.28-30. Puliafito, E., Guevara, M. and Puliafito, C. (2003). Characterization of urban air quality using GIS as a management system, Environmental Pollution, **122**, 105–117.

Robinson, M., Cognard-Plancq, A. L., Cosandey, C., David, J., Durand, P., Fuhrer, H. W., Hall, R., Hendriques, M. O., Marc, V., McCarthy, R, McDonell, M., Martin, C., Nisbel, T., O'Dea, P., Rodgers, M. and Zollner, A. (2003). Studies of the impact of forests on peak flows and baseflows: a European perspective. Forest Ecology and Management, **186**, 85-94.

Suárez García, M. A., Butler, J. C. and Baillie, M. (2009). Climate signal in tree-ring chronologies in a temperate climate: a multi-species approach .Dendrochronologia, **27 (3)**, 183-198.

Takagi, M. and Gyokusen, K. (2004). Light and atmospheric pollution affect photosynthesis of street trees in urban environments. Urban forestry and Urban Greening, **2 (3)**, 167-171.

Unterbrunner, R., Puschenreiter, M., Sommer, P., Wieshamer, G. (2007). Heavy metals accumulation in trees growing on contaminated sites in Central Europe, Environmental Pollution **148**, 107-114.

USEPA, (2009). A Guide to Air Quality and your health, Environmental Protection Agency.