

## WOODEN SPECIES IN THE URBAN GREEN AREAS AND THEIR ROLE IN IMPROVING THE QUALITY OF THE ENVIRONMENT

Anișoara Stratu<sup>1</sup>, Naela Costică<sup>1</sup>, Mihai Costică<sup>1</sup>

**Keywords:** ornamental wooden species, environmental benefits

**Abstract:** The purpose of this paper is to underline the role of some wooden species in different units of green areas in Iasi municipality in improving the quality of the environment. By regular visits in the field, we have identified the wooden species frequent in different areas; based on the bibliography in the field, we underlined the ecological characteristics, the resistance to unfavourable climate factors, and the role of these species in improving the quality of the environment. Most species taken into account are resistant to extremely cold weather and to drought; are considered resistant (*Acer negundo*, *Acer pseudoplatanus*, *Hibiscus syriacus*, *Ligustrum vulgare*) or present moderate resistance (*Aesculus hippocastanum*, *Acer platanoides*, *Philadelphus coronarius*) to polluting elements in the atmosphere. The wooden species considered in this study have profound influence on the environment: they regulate the urban microclimate; they contribute to the concentration reduction of some atmospheric pollutants, the noise level; they improve the edaphical conditions and contribute to the soil consolidation. Some species can be used as bio-monitors of the pollution in urban areas.

### Introduction

Studies done by different authors have underlined the role of the urban green areas and also the role of the wooden species cultivated in the urban green areas in reducing the level of pollution in the cities, regulating the urban microclimate (Nowak et al., 1998; Giorgi and Zafiriades, 2006; Makhelouf 2009, 2013; Mitchell et al., 2010; Yang et al., 2010; Simon et al., 2011).

Some wooden species can be used as bio-indicators to estimate the degree of air pollution in the urban areas (Aksoy and Sahin, 1999; Aksoy et al., 2000; Kurteva and Stambolieva, 2007; Oroian et al., 2012; Petrova et al., 2012; 2014).

The objectives of the paper were: identifying frequent wooden species in different areas of green spaces in Iasi; highlighting the role of these species in improving the quality of the environment.

---

<sup>1</sup> „Alexandru Ioan Cuza” University, Faculty of Biology, I Carol I Bd., No. 20 A, 700506, Iași, Romania  
anisoara\_stratu@yahoo.com

## 1. Materials and Methods

To achieve the objectives set, we went periodically in the field in the period April 2013 - May 2015 and identified wooden species frequent in different units of green areas (Junimea park, Nicolina esplanade, Podu Roş park; green spaces in the area Podul Roş) in Iasi. Species determinations were done using specialized books published by Dumitriu Tătăranu (1960), Zanoschi et al., (1996; 2000), Ciocârlan (2000), Clinovschi (2005). Based on the bibliography in the field, we underlined the ecological characteristics, the resistance to unfavourable climate factors and the role of these species in improving the quality of the environment.

## 2. Results and discussions

*2.1. Ecological characteristics and resistance to unfavourable climate conditions.* We identified 23 ornamental wooden species (13 species of trees and 10 species of bushes) as being frequent in the units of green areas taken into the study (Table 1a, 1b).

Table 1a. The ecological characteristics of the trees species (Doniță et al., 1977; Iliescu 1998; Clinovschi, 2005)

Species / Family	Origin	Ecological indices			
		The preferences for soil trophicity	The preferences for soil humidity	The preferences for temperature	The preferences to light
<i>Acer platanoides</i> L. (Aceraceae)	indigenous	eutrophic	mesophyllous	moderate thermophile	helio-sciophyllous
<i>Acer pseudoplatanus</i> L. (Aceraceae)	indigenous	mesotrophic-eutrophic	mesophyllous-mesohigrophilous	moderate thermophile	heliosciophyllous / sciophyllous
<i>Acer negundo</i> L. (Aceraceae)	America	mesotrophic	mesophyllous	moderate thermophile	sciophyllous
<i>Aesculus hippocastanum</i> L. (Hippocastanaceae)	Balkan peninsula	eurytrophic	xerophyllous	moderate thermophile	heliophyllous
<i>Ailanthus altissima</i> Mill. Swingle (Simarubaceae)	China	eurytrophic	xerophyllous	subtermophile	heliophyllous
<i>Betula pendula</i> Roth. (Betulaceae)	indigenous	oligotrophic	eurypyllous	eurythermophile	heliophyllous
<i>Catalpa bignonioides</i> Walt. (Bignoniaceae)	North America	eutrophic	eurypyllous	subthermophile	heliophyllous
<i>Picea abies</i> (L.) Karst. (Pinaceae)	indigenous / Central Europe	mesotrophic	mesophyllous	oligothermophile	heliosciophyllous
<i>Pinus nigra</i> Arn. (Pinaceae)	Southeast Europe	oligotrophic-mesotrophic	xerophyllous	moderate thermophile	heliophyllous
<i>Pinus sylvestris</i> L. (Pinaceae)	indigenous	oligotrophic	xerophyllous	eurythermophile	heliophyllous
<i>Robinia pseudoacacia</i> L. (Fabaceae)	North America	oligotrophic	xerophyllous	subthermophile	heliophyllous
<i>Tilia cordata</i> Mill. (Tiliaceae)	indigenous	eutrophic/mesotrophic	mesoxerophyllous-mesophyllous	moderate thermophile	heliophyllous heliosciophyllous
<i>Tilia tomentosa</i> Moench. (Tiliaceae)	indigenous	eutrophic-mesotrophic	mesophyllous-mesohigrophilous	subthermophile	heliophyllous - heliosciophyllous

These species are either local (*Acer platanoides*, *Acer pseudoplatanus*, *Tilia cordata*, *Tilia tomentosa*, *Cornus sanguinea*) or acclimatised (*Acer negundo*, *Catalpa bignonioides*, *Robinia pseudoacacia*, *Hibiscus syriacus*, etc) (Table 1a, 1b). They present decorative value conferred by the shape of the plant, of its crown, the size and colour of the leaves, flowers, fruit, the characteristics of the bark.

Table 1b The ecological characteristics of the bushes species (Doniță et al., 1977; Ilescu 1998; Clinovschi, 2005 )

Species/Family	Origin	Ecological indices			
		The preferences for soil trophicity	The preferences for soil humidity	The preferences for temperature	The preferences for light
<i>Buxus sempervirens</i> L. (Buxaceae)	Meditereanean basin	large ecological amplitude	xerophyllous	moderate thermophile	large ecological amplitude
<i>Cornus sanguinea</i> L. (Cornaceae)	indigenous	mesotrophic	mesoxerophyllous-mesohigrophyllous	moderate thermophile	heliophilous-helio-sciophyllous
<i>Elaeagnus angustifolia</i> L. (Elaeagnaceae)	Asia	oligotrophic	xerophyllous	moderate thermophile	heliophyllous
<i>Hibiscus syriacus</i> L. (Malvaceae)	China and India	eurytrophic	mesophyllous	subthermophile	heliophyllous
<i>Ligustrum vulgare</i> L. (Oleaceae)	indigenous	mesotrophic / eutrophic	mesoxerophyllous - mesophyllous	moderate thermophile	heliophyllous-heliosciophyllous
<i>Philadelphus coronarius</i> L. (Saxifragaceae)	South Europe	large ecological amplitude	xerophyllous	moderate thermophile	heliophyllous – helio-sciophyllous
<i>Spiraea x vanhouttei</i> L. (Rosaceae)	Central Europa	eutrophic	mesophyllous	moderate thermophile	helio-sciophyllous
<i>Tamarix tetrandra</i> Pall. (Tamaricaceae)	Europa	large ecological amplitude	xerophyllous	subthermophile	heliophyllous
<i>Thuja occidentalis</i> L. (Cupressaceae)	North America	mesotrophic	mesohigrophyllous	eurythermophile	heliophyllous
<i>Thuja orientalis</i> L. (Cupressaceae)	China, Russia	mesotrophic	xerophyllous	micro-nesothermophile	heliophyllous

The wooden species taken into the study present varied ecological characteristics (Table 1a, 1b): 10 species (41.66%) are xerophyllous; 12 species (52.17 %) are heliophyllous; 6 species (26.08 %) are heliophyllous – helio-sciophyllous; 12 species (52.17 %) are moderate thermophile; 5 species (21.73 %) are mesotrophic, and 3 species (13.04%) have large ecological amplitude regarding the trophicity of the soil.

As for the resistance to unfavourable climatic conditions (Table 2), it was noticed the fact that most species taken into the study are resistant to frost (79.16 %) and drought (62.5 %).

The ecological factors in the urban environment influence the life of plants. In the city, the concreted and asphalted surfaces tend to gather heat instead of reflecting it, contributing to the raise of temperature comparing to the outer areas,

and to the manifestation of the phenomenon called urban heat island, with consequences on the local species (Grimm et al., 2008). On their turn, the plants have strong influences on the environment, determining its modification (Iliescu, 1998).

2.2 *The role of the wooden species in improving the quality of the environment.*

2.2.1. *Regulate the urban microclimate.* A) They contribute to the increase of the relative humidity of the atmosphere by 7-14 %, in the hot season, due to the water eliminated by the process of transpiration at the level of leaves (Sonea et al., 1979).

According to Souch and Souch (1993), at noon and in the evening, the relative humidity of the air under the tree crowns was by 27% - 33% higher than in the open. Research carried out by Giorgi and Zafiriades (2006), during summer, in wooden species cultivated in parks in Thessaloniki (Greece) showed the fact that the humidity of the air under the tree crowns varied according to the species and was higher comparing to that measured under the sun: by 23.3 % at *Aesculus hippocastanum*; 16.7 % at *Ailanthus altissima*; 15.1 % at *Robinia pseudoacacia*; 14.6 % at *Acer negundo*, 11.7 % at *Catalpa bignonioides*.

B) They reduce the temperature of the air, especially in the hot season, due to the transpiration of the leaves, but also the effect of shadowing. Under the influence of the green areas, the temperature of the air is influenced until a distance of 1km (Sonea et al., 1979). Preliminary research done by Taha et al., (1988) (quoted by Souch and Souch 1993, and by Giorgi and Zafiriades, 2006), showed the fact that during the day the temperature of the air under the tree leaves in the green areas was 1.7- 3.3<sup>0</sup>C lower than in the areas without trees. Similar observations were done by Souch and Souch (1993) in Bloomington, Indiana (USA): the temperature of the air at noon under the tree crowns was 0.7 – 1.3<sup>0</sup>C lower comparing with that in the open areas. Research done by Giorgi and Zafiriades, (2006), in species of trees cultivated in parks in Thessaloniki (Greece) showed the fact that the temperature of the air under the tree crowns between 1:00 pm and 3 pm was lower comparing with the temperature measured under the sun and it varied according to the species: by 9.7 % at *Aesculus hippocastanum*; 7.7 % at *Ailanthus altissima*; 7.1 % at *Robinia pseudoacacia*; 7 % at *Acer negundo*; 6.4 % at *Catalpa bignonioides*.

Research done by Makhelouf (2009, 2013) showed the fact that during the hot period, the differences of temperature and humidity between the green areas (measuring done in the park Bois de Boulong, Paris – large green area with a surface of 855ha) and the built areas in the neighbourhood were insignificant in the morning and significant in the afternoon. The variation of temperature between the

central area of the park Bois de Boulogne and the residential areas in the neighbourhood was of 3<sup>0</sup>C.

Table 2. The resistance of the wooden species to unfavourable climate conditions (Dumitriu – Tătăranu, 1960; Sonea et al., 1979; Iliescu, 1998)

Species	Resistance/sensitivity to frost	Resistance /sensitivity to drought
<i>Acer pseudoplatanus</i>	resistant	resistant
<i>Acer platanoides</i>	resistant	resistant
<i>Acer negundo</i>	sensitive	resistant
<i>Aesculus hippocastanum</i>	resistant	resistant
<i>Ailanthus altissima</i>	sensitive	resistant
<i>Betula pendula</i>	resistant	sensitive to excessive atmospheric drought
<i>Buxus sempervirens</i>	resistant	resistant
<i>Catalpa bignonioides</i>	resistant	sensitive
<i>Cornus sanguinea</i>	resistant	resistant
<i>Elaeagnus angustifolia</i>	resistant	resistant
<i>Hibiscus syriacus</i>	moderate resistance to frost	resistant
<i>Ligustrum vulgare</i>	resistant	resistant
<i>Picea abies</i>	resistant	
<i>Pinus nigra</i>	resistant	tolerance
<i>Pinus sylvestris</i>	resistant	resistant
<i>Philadelphus coronarius</i>	resistant	low resistance
<i>Robinia pseudoacacia</i>	moderate resistance	resistant
<i>Spiraea x vanhouttei</i>	resistant	resistant
<i>Tamarix tetrandia</i>	resistant	resistant
<i>Tilia cordata</i>	resistant	sensitive
<i>Tilia tomentosa</i>		adaptable to drought
<i>Thuja occidentalis</i>	resistant	resistant
<i>Thuja orientalis</i>	low resistance	

Trees reduce the effect of heat island in the urban environment that appears due to the existence of large areas of surfaces that store thermal energy (asphalted streets, buildings from heat-absorbing materials, etc.). Because of this effect, the temperature of the air in the urban environment raises by a few degrees comparing to the suburban environment.

C) They determine the formation of urban breezes, following the temperature differences of the air between the green areas and the neighbouring areas (occupied by buildings or lacking vegetation) (Muja, 1994). These breezes present reduced speed (they are less than 2m/s) (Makhelouf, 2013) and contribute to the purification of the air and the cooling/increase of its relative humidity during summer.

D) They reduce the intensity of the direct and diffuse solar radiation on summer days. The leaves of the wooden species intercept, absorb and reflect the solar radiations, and thus reduce the intensity of the radiation that reaches the soil (Makhelouf, 2013). It is considered that this capacity is higher in the deciduous plants that present large and compact crowns. Among the species considered in this

study, large and compact crowns have the species *Aesculus hippocastanum*, *Acer platanoides*, *Acer pseudoplatanus*, *Tilia cordata*.

Experimental studies carried out in Israel, proved the fact that the intensity of the solar radiation measured under the tree crowns represented 10% of the intensity of the solar radiation measured in the areas exposed to sun (Givoni et al., 2003). According to Giorgi and Zafiriades (2006), the leaves of some ornamental wooden species absorb or reflect during summer a high percentage of solar radiation: 95.7 % at *Aesculus hippocastanum*; 95.5 % at *Ailanthus altissima*; 94.1 % at *Robinia pseudoacacia*; 93.5 % at *Acer negundo*; 92.7 % at *Catalpa bignonioides*.

2.2.2 Reduce the concentration of the polluting substances in the atmosphere at local level. A) Through the process of photosynthesis, the wooden vegetation contributes to the reduction of the excess of CO<sub>2</sub> (the main gas with greenhouse effect) in the atmosphere of the urban environment and the regeneration of the reserve of oxygen necessary to the respiration of live organisms. It was estimated that one ha of urban plantation absorbs in 8 hours a quantity of 8kg of CO<sub>2</sub>; this quantity is equivalent to that breathed out by 20 persons during the same period of time (Muja, 1994).

B) The wooden plants contribute to the reduction of the concentration of polluting substances in the atmosphere (material particles, gas, aerosols) by retaining/depositing on the organs above the ground and by the metabolism of some chemical compounds, being considerate true biological filters. The highest filtering potential is against powders (Mănescu et al., 1994). It falls on leaves and other organs above the ground (branches, trunk), which are periodically washed by rains, and thus the filter capacity is remade. Powders come from natural and anthropic sources (traffic, industry, other common activities). According to Mănescu et al., (1994), the phenomenon of retaining powders is due to several factors: reducing the wind speed, modification of atmospheric turbulence, the property of the leaves/other organs above the ground to fix particles in suspension.

In the case of the leaves, the capacity to retain material particles (powders, dust) is influenced by the morphological characteristics of the foliar limb: large foliar surface; the aspect of the foliar surface, the presence of hairs, protruding nervures. The leaves with a ribbed, harsh surface of the limb, with hairs or that contain wax can capture a larger quantity of particles (Yang et al., 2005; Mitchell et al., 2010). The species *Tilia platyphyllos* and *Betula pendula* attract aphids; because of the sweet-sticky products of metabolism of the aphids, the surface of the leaf becomes sticky, which can favour the deposit of particles (Mitchell et al., 2010). The research done by Saebo et al., (2011) showed the fact that the species *Pinus sylvestris* and *Betula pendula* have increased efficiency in capturing the powders on the leaves (three fractions of powders: PM10, PM2.5, PM 0.2), and the species *Acer platanoides*, *Acer pseudoplatanus*, *Tilia cordata* and *Robinia*

*pseudoacacia* have reduced efficiency. In the opinion of the authors mentioned, an important characteristic in accumulating particles on leaves is the presence of hairs and the content of wax on the leaf surface. The potential of filtration of the leaves was estimated to be of 20g particles of dust/ m<sup>2</sup> of foliar surface (www.ec.europa.eu/).

Regarding the powders in suspension, those with diameter less than 10 microns (fractions PM10 and PM2.5) have a limited capacity of diffusion, presenting adverse effects on man and environment. PM10 and PM2.5 represent important indicators of air quality.

The analysis of the elements in the composition of the dust deposited on the surface of the leaves of *Tilia cordata*, *Tilia tomentosa*, *Aesculus hippocastanum* (Tomasevic and Anicic, 2010) and *Acer pseudoplatanus* (Simon et al., 2011) underlined the presence of heavy metals (Fe, Cu, Zn, Pb, etc.) and other elements (Si, Ca, Mg, Cl, K, N, S, etc.).

Some gas polluting substances (sulphur dioxide, nitrogen oxides, etc.) and heavy metals can be retained by the wooden plants and metabolised to a lesser extent. A sample of *Acer platanoides* aged 50 absorbs during its period of vegetation 0.095kg of sulphur, 0.0860kg of chlorine and 0.0039kg of fluorine (www.ec.europa.eu/).

The resistance of wooden plants to pollution is much studied; it is relative and it varies according to several factors (species, variety, age, nature of polluting substances concentration, time of exposure, pedoclimatic conditions, etc.) (Smejkal, 1982; Bolea et al., 2006).

The species taken into the study present different degrees of resistance to pollution substances in the atmosphere. Some species are sensitive to the pollution substances in the atmosphere (*Picea abies*, *Pinus sylvestris*, *Tilia cordata*); others are resistant (*Pinus nigra*, *Thuja orientalis*, *Acer pseudoplatanus*, *Acer negundo*, *Ailanthus altissima*, *Buxus sempervirens*, *Cornus sanguinea*, *Hibiscus syriacus*, *Ligustrum vulgare*, *Robinia pseudoacacia*, *Spiraea x vanhoutei*) or have middle resistance (*Acer platanoides*, *Aesculus hippocastanum*, *Philadelphus coronarius*) (Ionescu, 1982; Iliescu, 1998). Comparing with the deciduous plants, the coniferous are more sensitive to pollution but filter (capture solid particles) and refresh the air better than the deciduous plants (Smejkal, 1982). The behaviour of the species considered for this study towards the sulphur dioxide varies as follows: some species are considered resistant (*Acer platanoides*, *Acer pseudoplatanus*, *Hibiscus syriacus*, *Ligustrum vulgare*), other species present moderate resistance (*Aesculus hippocastanum*, *Betula pendula*, *Robinia pseudoacacia*, *Buxus sempervirens*, *Catalpa bignoniodes*, *Philadelphus coronarius*) or are sensitive (*Pinus sylvestris*, *Picea abies*) (Ionescu 1982). The metabolism capacity of the sulphur according to the specialty data varies as follows: *Betula pendula* -

8724pppm, *Pinus sylvestris* - 2200ppm, *Picea abies* - 1290ppm, *Thuja occidentalis* - 929ppm (Bolea et al., 2006).

Some wooden species can be used in the bio-monitoring of the air quality in urban areas (as bio-indicators/bio-accumulators): *Aesculus hippocastanum* (Tomasevic and Anicic, 2010; Anicic et al., 2011; Oroian et al., 2012; Petrova et al., 2012); *Acer pseudoplatanus* (Kurteva and Stambolieva, 2007; Simon et al., 2011); *Acer platanoides* (Kurteva and Stambolieva, 2007); *Elaeagnus angustifolia* (Aksoy and Sahin, 1999); *Robinia pseudoacacia* (Aksoy et al., 2000), *Betula pendula* (Kurteva and Stambolieva, 2007; Oroian et al., 2012, Petrova et al., 2014).

It is known the fact that with the gas changes, the wooden species emit volatile organic compounds (mainly from the group of isoprenoids and terpenes) that are precursors of ozone formation (secondary polluting substance of the atmosphere) (Calfapietra et al., 2013). The emission of volatile organic compounds varies according to the species and it is strongly dependent on temperature. Maintaining low temperature due to the transpiration can reduce the ozone concentration (Nowak et al., 1998; Yang et al., 2005).

Also, the wooden plants have the role of microbial purge of the air given to the emission of substances with antimicrobial properties (Muja, 1994).

**2.2.3 Reduce the level of noise pollution.** The wooden plants reduce the intensity of noise produced by traffic and other external sources of noise pollution (industrial activities, construction activities, etc). Noise can create health problems to the population in urban environment (increase of tiredness, less ability to focus, reduced attention, modifications at cardio-respiratory level, etc). The tree and bush crowns absorb approximately 26 % of the sound energy, representing a barrier against noise and contributing to reducing the noise pollution (Muja, 1994). Plants reduce the noise by reflection, refraction, absorption, interference and diffraction (Yang et al., 2010). The capacity to reduce the noise intensity depends on the species, density of crown, height of the crown, location of the plantation comparing with the source of noise, the distance from the source of noise, the composition and structure of the plantation, etc., season of vegetation (Yang et al., 2010; Muja, 1994). The species *Acer pseudoplatanus* and *Tilia platyphyllos* reduce the noise intensity by 10 - 12 db, respectively by 8-10 db. The species *Acer negundo*, *Betula pendula*, *Cornus sanguinea* reduce the noise intensity by 4 - 6dB, *Ligustrum vulgare* by 2-4 dB, and *Buxus sempervirens* and *Spiraea x vanhouttei* by 2dB (Muja, 1994; Yazgan 1976 quoted by Erdogan and Yazgan 2009).

**2.2.4 They influence favourably the edaphical conditions.** The wooden species determine modifications in the edaphical conditions: they modify the soil pH, the cations proportion, influence the regime of mineral substances; enrich the structure and permeability of the soil, etc. (Doniță et al., 1977) Most wooden

species form mycorrhizae that enlarge the surface of contact with the soil and favour the absorption of the water and mineral salts. Also, they help plants to live in places with few nutritive substances or in an environment that limits the accessibility to nutrients. For the species considered in the study, in the literature in the field are quoted the following types of mycorrhizae: arbuscular mycorrhizae (*Acer pseudoplatanus*, *Acer platanoides*, *Aesculus hippocastanum*, *Buxus sempervirens*, *Cornus sanguinea*, *Ligustrum vulgare*, *Thuja occidentalis*); ectomycorrhizae (*Betula pendula*, *Pinus sylvestris*, *Robinia pseudoacacia*, *Tilia cordata*). Some species can form several types of mycorrhizae (*Acer pseudoplatanus*, *Acer platanoides*, *Robinia pseudoacacia*) or can be mycorrhiza and non mycorrhiza (*Cornus sanguinea*, *Acer pseudoplatanus*, *Acer platanoides*) (Wang and Qiu, 2006).

Due to the well-developed rooting system, the wooden species fix and consolidate the soil, reducing the trepidations.

For the wooden plants in the street alignment, those in intensely asphalted areas, etc. the conditions of the environment are less favourable: reduced volume of soil, caught in the pavement, limited by underground constructions, subject to being stepped by passers-by; extremely positive temperatures during summer (Iliescu, 1998). These conditions can act as stressful factors for plants and can affect the health of plants, thus reducing their benefits.

### Conclusions

The wooden species considered in this study have profound influence on the environment, determining modifications to it in a positive sense: they regulate the urban microclimate; they act like biological filter, contributing to reducing the concentration of some polluting substances in the atmosphere, the noise level; they improve the edaphical conditions and contribute to the soil consolidation. Some species can be used as bio-monitors of the pollution in urban areas.

### References

- Aksoy, A., Sahin U., (1999), *Elaeagnus angustifolia L. as a biomonitor of heavy metal pollution*, Tr. J. of Bot., 23, 83-87.
- Aksoy A., Sahin U., Duman F., (2000), *Robinia pseudo-acacia L. as a possible biomonitor of heavy metal pollution in Kayseri*, Turk. J. Bot., 24, 279 - 284.
- Bolea V., Chira D., Popa M., Mantale C., Pepelea D., Gancz D., Surdu Aurelia, Iacoban Carmen, (2006), *Arborii bioindicatori și biacumulatori de sinteză în ecosistemul forestier*, Analele ICAS, 49, 67-77.
- Calfapietra C., Fares S., Manes F., Morani A., Sgringa G., Loreta F., (2013), *Role of biogenic volatile organic compounds (BVOC) emitted by urban trees on ozone concentration in cities, A review*, Environmental pollution, 183, 71 - 80.

- Ciocarlan V.**, (2000), *Flora ilustrată a României (Pteridophyta et Spermatophyta)*, Ed. Ceres, București, 1140 pp.
- Clinovschi F.**, (2005), *Dendrologie*, Ed. Universității, Suceava, 35-69, 83-279.
- Doniță N., Ceianu I., Beldie A.**, (1977), *Ecologie forestieră (cu elemente de ecologie generală)*, Ed. Ceres, București, 110, 267-273
- Dumitriu - Tătăranu I.**, (1960), *Arbori și arbuști forestieri și ornamentalii cultivați în R. P. R.*, Ed. Agro-Silvică, București, 810 pp
- Erdogan E., Yazgan E. M.**, (2009), *Landscaping in reducing traffic noise problem in cities: Ankara case*, African Journal of Agricultural Research, 4,10, 1015-1022.
- Giorgi N. J., Zafiriades K.**, (2006), *The impact of park trees on microclimate in urban areas*, Urban Ecosyst, 9, 195 – 209.
- Givoni B., Noguchi M., Saaroni H., Pochter O., Yaacov Y., Feller N., Becker S.**, (2003), *Outdoor comfort research issues*, Energy and Buildings, 35, 77- 86.
- Grimm N.B., Faeth S.H., Golubiewski N. E., Redman C.L., Wu J., Bai X., Briggs J.M.**, (2008), *Global change and ecology of cities*, Science, 319,756 -760.
- Iliescu Ana Felicia**, (1998), *Arboricultură ornamentală*, Ed. Ceres, București, 26-47, 233 - 387
- Ionescu A.**, (1982), *Fenomenul de poluare și măsuri antipoluante în agricultură*, Ed. Ceres, București, 164-175,197-203.
- Kurteva Maya, Stambolieva Katerina**, (2007), *Acer pseudoplatanus L., Acer platanoides L. and Betula pendula Roth. as bioindicators of urban pollution in Sofia*, Silva Balcanica, 8, 1, 32 – 46.
- Makhelouf A.**, (2009), *The effect of green spaces on urban climate and pollution*, Iran. J. Environ. Health. Sci. Eng., 6, 1, 35 - 40.
- Makhelouf A.**, (2013), *The contribution of urban green spaces in the regulation of the microclimate and the improvement of the air quality in cities*, Asian Journal of Current Engineering and Maths, 2, 190 - 195.
- Mănescu S., Cucu M., Diaconescu Mona Ligia**, (1994), *Chimia sanitară a mediului*, Ed. Medicală, București, 174-187.
- Mitchell R., Maher B. A., Kinnersley R.**, (2010), *Rates of particulate pollution deposition onto leaf surfaces: temporal and inter-species magnetic analysis*, Environmental Pollution, doi:10.1016/j.envpol.200912.029.
- Nowak D. J., Mettala P. J., Ibarra M., Crane D., Stevens J. C., Luley C. J.**, (1998), *Modeling the effects of urban vegetation on air pollution*, Air Pollution Modeling and its Applications, XII, 399-407.
- Oroian I. Gh., Covrig I., Viman Oana, Odagiu Antonia, Burduhos P., Milășan A., Șulea C.**, (2012), *Testing biomonitoring capacity of trees from urban areas. A case study: Cu, Cd, Pb, Zn pollution in Cluj - Napoca, reflected by foliar accumulation of five species located within intense traffic area. Note 1. Results recorded in 2010*, ProEnvironment, 5, 195-199.
- Petrova Slaveya, Iurukova Lilyana, Velcheva Iliana**, (2014), *Possibilities of using deciduous tree species in trace element biomonitoring in an urban area (Plovdiv, Bulgaria)*, Atmospheric Pollution Research, 5, 196 - 202.

- Petrova Slaveya, Iurukova Lilyana, Velcheva Iliana**, (2012), *Horse chestnut (Aesculus hippocastanum L.) as a biomonitor of air pollution in the town of Plovdiv (Bulgaria)*, J. BioSci. Biotech., 1, 3, 241 - 247.
- Saebo A., Popek R., Nawrot B., Hanslim H. M., Gawronska H., Gawronski S. W.**, (2012), *Plant species differences in particulate matter accumulation on leaf surfaces*, Science of the Total Environment, 427 – 428, 347 - 354.
- Simon E., Braun M., Vidic A., Bogió D., Fábíán I., Tóthmérész B.**, (2011), *Air pollution assesment based on elemental concentration of leaves tissue and foliage dust along an urbanization gradient in Vienna*, Environmental Pollution, 159, 1229-1233.
- Smejkal G.**, (1982), *Pădurea și poluarea industrială*, Ed. Ceres, București, 13-25, 170-179.
- Sonea V., Palade L., Iliescu Ana Felicia**, (1979), *Arboricultură ornamentală și arhitectură peisageră*, Ed. Didactică și Pedagogică, București, 40 - 158, 203 - 205.
- Souch C.A., Souch C.**, (1993), *The effect of trees on summertime below canopy urban climates: a case study Bloomington, Indiana*, Journal of Arboriculture, 19, 5, 303 - 312.
- Tomašević M., Aničić M.**, (2010), *Trace element content in urban tree leaves and sem-edax characterisation of deposited particles*, Facta Universitatis, Series: Physics, Chemistry and Technology, 8, 1, 1 - 13.
- Wang B., Qiu Y. L.**, (2006), *Phylogenetic distribution and evolution of mycorrhizas in land plants*, Mycorrhiza, 16, 299 - 363.
- Yang J., McBride J., Zhou J., Sun Z.**, (2005), *The urban forest in Beijing and its role in air pollution reduction*, Urban Forestry&Urban Greening, 3, 65-78.
- Yang F., Zhu Z., Liu J.**, (2010), *The investigation of noise attenuation by plants and the corresonding noise-reducing- spectrum*, Journal of Environmental Health, 72, 8, 8-15.
- Zanoschi V., Sârbu I., Toniuc Angela**, (1996), *Flora lemnoasă spontană și cultivată din Romania, Încrengătura Angiospermatophyta*, vol. I, Ed. Glasul Bucovinei, Iași, 82-107
- Zanoschi V., Sârbu I., Toniuc Angela**, (2000), *Flora lemnoasă spontană și cultivată din Romania, Încrengătura Angiospermatophyta*, vol. II, Ed. Univ. „Al. I. Cuza”, Iași, 19 - 38, 57 - 79.
- [http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=UrbEco\\_Leaflet.pdf](http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=UrbEco_Leaflet.pdf)

