# PHYSIOLOGICAL AND BIOCHEMICAL CHANGES AT FOLIAR LEVEL INDUCED BY ATMOSPHERIC POLLUTANTS ON SAMPLES OF *AESCULUS HIPPOCASTANUM* L. FROM IAŞI CITY AREA

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**Keywords**: *Aesculus hippocastanum* L., atmospheric pollutants, physiological changes
**Abstract:** We present in this paper some physiological changes (photosynthetic and transpiration processes intensity) and biochemical (content of photo-assimilating pigments) induced at foliar level by some pollutants in samples of *Aesculus hippocastanum* L. cultivated for ornamental purposes across the five air quality monitoring stations in Iasi city area. Pollutants monitored by the five stations are represented by gaseous (sulphur dioxide, carbon dioxide, nitrogen dioxide, ozone) and solid pollutants (dust prone to sedimentation). Measurements were made *in vivo*, as well on fresh material covering vegetation periods of years 2012 and 2013. The necrosis and the inducted foliar chlorosis by polluting agents represent the clear materialization of some profound physiological modifications which disturb the photo-assimilating structures and assimilator pigments. The results lead to the conclusion that the amount of chlorophyll a and b and the intensity of photosynthesis aren't always correlated, as already known from literature. The most obvious results of pollutants influence occurred for the individuals situated at the traffic station Podul de Piatră, where $SO_2$ and particulate solids in suspension are the predominating pollutants and this fact states that the traffic pollutants are the most destructive.

## INTRODUCTION

Urban air pollution has become a serious environmental problem to trees and crops (Chauhan and Joshi, 2008). Plants are the only living organisms which [3] have to suffer a lot from automobile exhaust pollution because they remain static at their habitat (Mandal, 2006). It has been reported that gaseous forms are absorbed by the leaves, while the particulate forms are absorbed through the outer surface of the plants. Affected plants show some common effects such as chlorosis, necrosis and inhibition in photosynthesis and decreasing plant growth (Davison and Blakemore, 1976). Several studies have shown the impact of automobile exhaust on roadside vegetation throughout their visible and nonvisible effects (Joshi and Swami, 2007).

When exposed to airborne pollutants, most plants experienced physiological changes before exhibiting visible damage to leaves (Liu and Ding, 2008). In recent past, air pollutants, responsible for vegetation injury and crop yield losses, are causing increased concern (Joshi and Swami, 2007). Pollutants can cause leaf injury, stomata damage, premature senescence, decreased photosynthetic activity, disturb membrane permeability and reduce growth and yield in sensitive plant species (Tiwari et. al, 2006). Reductions in leaf area and leaf number may be due to decreased leaf production rate and enhanced senescence. The reduced leaf area results in reduced absorbed radiations and subsequently in reduced photosynthetic rate (Tiwari et. al, 2006). In this paper we present the influence of atmospheric pollutants on photosynthetic and transpiration processes intensity and upon the content of photo-assimilating pigments in samples of *Aesculus hippocastanum* L. cultivated for ornamental purposes across the five air quality monitoring stations in Iasi city area.

## MATERIALS AND METHODS

The analyzed material consists of leaves belonging to *Aesculus hippocastanum* L. collected from around Iaşi city's air quality monitoring stations. Vegetal material was collected during the months of May, July and September of 2012- 2013. Control species were collected from the Botanical Garden of "Alexandru Ioan Cuza" University. Collection and measurement "in vivo" were made on leaves situated at the edge of the canopy, of the four cardinal points of each individual, at a distance of 4-5 m above the ground. It was taken into account the height above ground at which were mounted the air quality monitoring station's analyzers and the extent to which measurements of this analysis are relevant. For each foliar test we used 3 parallel probes, and the data was selected as the average value of the results.

Leaf's assimilating pigments were determined by spectrophotometric method of Arnon (1949). They were determined in 80% acetone extract, colorimetred at the following wave length: 663nm, 646nm and 470nm. The results were calculated using formulas developed by MacKinney (1941) and the values were expressed in mg $100g^{-1}$ plant material.

To analyze the functional parameters - process of photosynthesis (A), respiration (R) and foliar transpiration (E) it has been used the LCi portable photosynthesis measurement system. Recording parameters was performed *in vivo* on a number of five leaves from the four cardinal points of each individual analyzed (three individuals of the same species in each determination). Therefore the results are the arithmetic mean of readings taken.

## RESULTS AND DISCUSSIONS

Net photosynthetic rate is a measure commonly used in the study of the impact of air pollutants on woody species (Woo et al., 2007). Plants are constantly exposed to environmental pollutants that they absorb, integrate and accumulate in their systems. It is reported that, depending on their level of sensitivity, the plants show visible changes that would include biochemical and physiological modification (Agba and Esiefarienrhe, 2009).

In all investigated areas the average of photosynthetic rate at *Aesculus hippocastanum* L. individuals was lower than the control in May, July and September of 2012 and 2013 (fig. 1, 2). The minimum photosynthetic rate was recorded at the individuals from Podu de Piatră area (traffic station). The photosynthesis rate was 46.15% from the control in May 2012 and 32.81% in May 2013, 39.95% from the control in July 2012 and 33% in July 2013, 40.37% from the control in September 2012 and 34.88% in September 2013.

The average of respiration values were very different, either lower or higher than the controls (fig.1, 2). The minimum values were recorded at the individuals from Podu de Piatră area (traffic station). The respiration process values were 52.17 % from the control in May 2012 and 51.85% in May 2013, 56.37% from the control in July 2012 and 49.11% in July 2013, 53.07% from the control in September 2012 and 35.8% in September 2013.

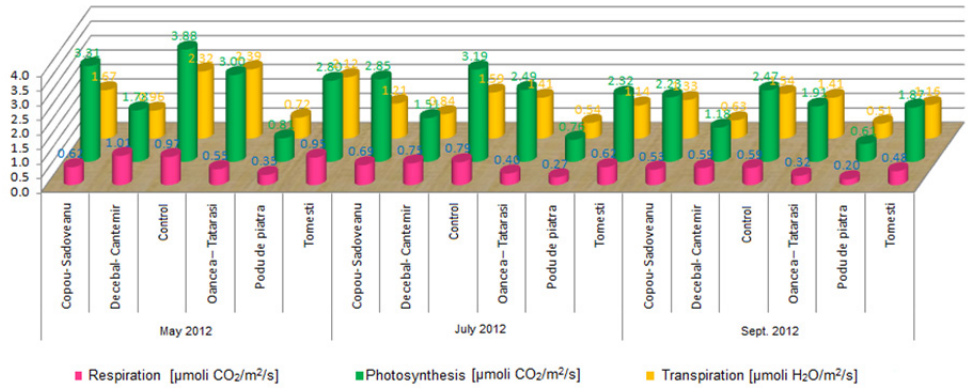


**Fig.1** Variation of physiological processes intensity: photosynthesis, respiration and transpiration at *Aesculus hippocastanum* L. individuals derived from the five areas of investigations (May. July and September 2012)

The average of transpiration values was very different, either lower or higher than the controls (fig.1, 2). The minimum values were recorded at the individuals from Podu de Piatră area (traffic station).The transpiration process value was 55.84% from the control in May 2012 and 38.62% in May 2013, 55.78% from the control in July 2012 and 56.91% in July 2013, 51.15% from the control in September 2012 and 50% in September 2013.

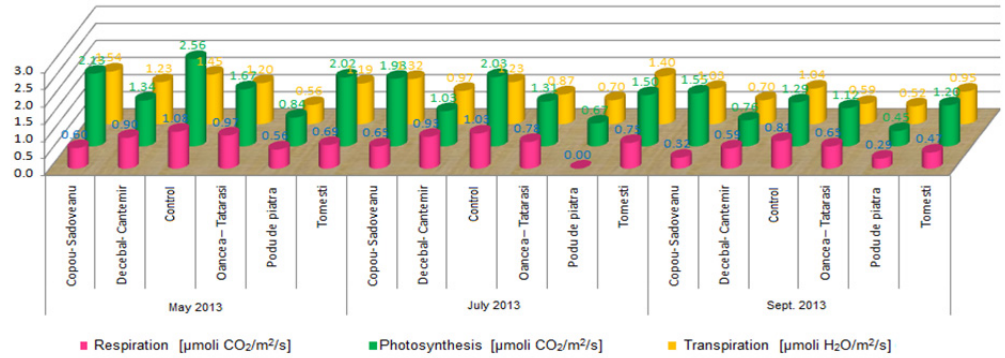


**Fig.2** Variation of physiological processes intensity: photosynthesis, respiration and transpiration at *Aesculus hippocastanum* L. individuals derived from the five areas of investigations (May. July and September 2013)

A relationship between traffic density and photosynthetic activity, total chlorophyll content and leaf senescence degree has been studied by Honour et al. in 2009. One of the most common effects of air pollution is the gradual disappearance of chlorophyll and yellowing leaves along with it, which as a consequence reduce photosynthesis (Joshi and Swami , 2007).

In all investigated areas the average amount of chlorophyll a, chlorophyll b and carotenoid pigments at *Aesculus hippocastanum* L. individuals were either lower or higher than the controls in May, July and September of 2012 and 2013 (fig. 3, 4).

The average of chlorophyll a amount was very different either lower or higher than the controls. Minimum values were recorded at the individuals of *Aesculus hippocastanum* L. species from Oancea-Tătăraşi area (industrial station). The average of chlorophyll a values was 51.70% from the control in May 2012 and 78.24% in May 2013, 53.89% from the control in July 2012 and 57.47% in July 2013, 39.24% from the control in September 2012 and 44.19% in September 2013.

The average of chlorophyll b amount was very different either lower or higher than the controls. Minimum values were recorded at the individuals of *Aesculus hippocastanum* L. species from Oancea-Tătăraşi area (industrial station). The average of chlorophyll b values was 61.35% from the control in May 2012 and 79.82% in May 2013, 57.60% from the control in July 2012 and 43.52% in July 2013, 27.78% from the control in September 2012 and 21.96% in September 2013.

The average of carotenoid pigments amount was very different either lower or higher than the controls. Minimum values were recorded at the individuals of *Aesculus hippocastanum* L. species from Oancea-Tătăraşi area (industrial station). The average of carotenoid pigments values was 92.42% from the control in May 2012 and 82.94% in May 2013, 75.05% from the control in July 2012 and 71.95% in July 2013, 62.40% from the control in September 2012 and 61.01% in September 2013.

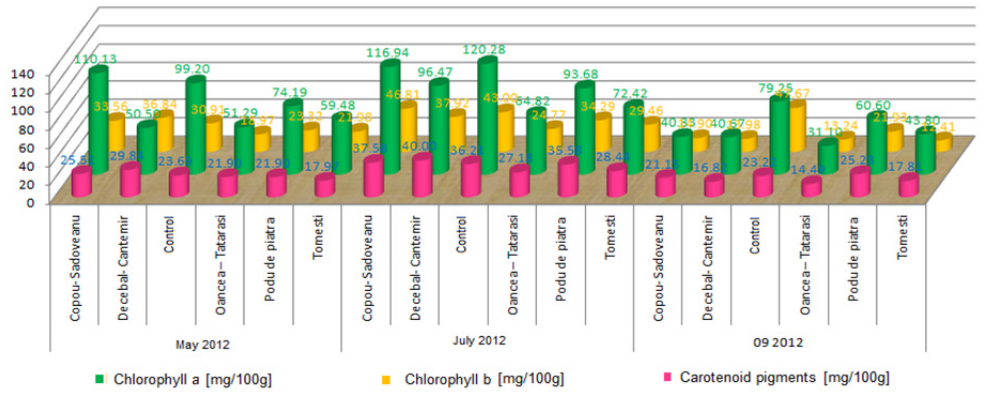


**Fig. 3** Variation of foliar pigments content (a chlorophyll, b chlorophyll and carotenoid pigments) at *Aesculus hippocastanum* L. derived from the five areas of investigations (May, July and September 2012)

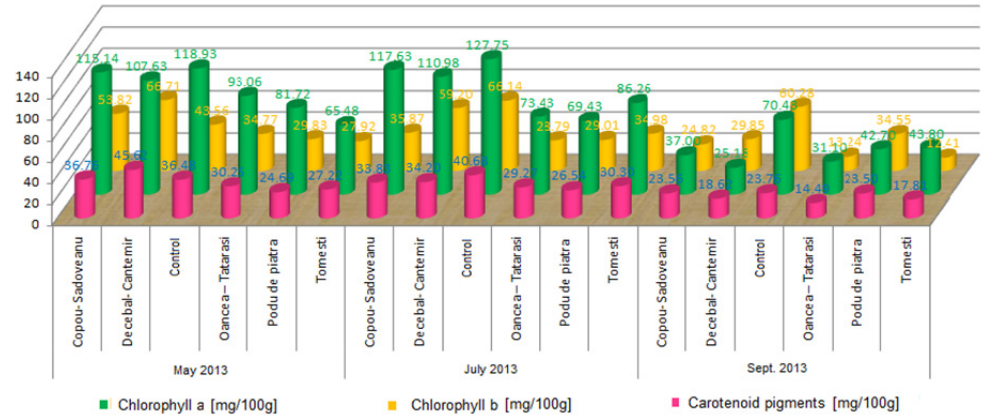


**Fig. 4** Variation of foliar pigments content (a chlorophyll, b chlorophyll and carotenoid pigments) at *Aesculus hippocastanum* L. derived from the five areas of investigations (May, July and September 2013)

Under the influence of solid and gas polluting agents the average of chlorophyll a, chlorophyll b and carotenoid pigments quantity can decrease. If the sulphur dioxide ($SO_2$), nitrogen oxides ($NO_x$) and $CO_2$ emissions and particulate matter are absorbed by the leaves, can cause a reduction in the concentration of photosynthetic pigments (chlorophylls and carotenoids) (Joshi and Swami, 2009).

## CONCLUSIONS

In this study we investigated the influence of atmospheric pollutants on photosynthetic and transpiration processes intensity and upon the content of photo-assimilating pigments in

samples of *Aesculus hippocastanum* L. cultivated for ornamental purposes across the five air quality monitoring stations in Iasi city area.

Although the polluting agents are different, we can notice similarities regarding the depression location of the two industrial zones, the presence of valleys and the air current circulation, with the greatest concentrations affecting the vegetations around the industrial platforms.

From the correlated interpretation of the obtained data, due to vegetation condition for the years 2012 and 2013 one can conclude that:

The “response” of each individual to pollutant aggression is conditioned by a multitude of genetic factors, pedo-climatic conditions, natural habitat and the nature of pollutant agent distance and it cannot be generalized for the representatives not even for the same genus.

Foliar necrosis and chlorosis are a clear proof of profound physiological modifications that affect the average amount of water, dry substance and assimilating pigments. If the sulfur dioxide (SO2), nitrogen oxides (NOx), CO2 emissions and particulate matter are absorbed by the leaves, can cause a reduction in the concentration of photosynthetic pigments (chlorophylls and carotenoids), which directly lead lower photosynthetic process (Joshi and Swami, 2009).

The minimum rate of photosynthesis, respiration and transpiration recorded at individuals from the Podu de Piatra area is explained by the presence of both coarse and fine particles resulting from heavy traffic. Both, fine and coarse particles, were reported to be responsible for increased leaf temperature that affecting transpiration and decreased light absorption, thus affecting photosynthesis (Tomašević and Aničić, 2012).

The lowest quantity of assimilating pigments was found at the individuals of *Aesculus hioppocastanum* L. species from Oancea-Tătăraşi area (industrial station). The amount of chlorophyll a, chlorophyll b and the intensity of photosynthesis aren’t always correlated.

It finds an irregularity regarding the response of this species to pollutants which makes us believe that further investigations are needed to complement the clinical symptomatology.

## REFERENCES

**Agbaire, P.O. and Esiefarienrhe,E.,** (2009*): Air Pollution Tolerance Indices (APTI) of some plants around Otorogun gas plant in Delta state, Nigeria. J.* Applied Sci. Environ. Manage., 13: 11-14.

**Burzo, I.,** (1999):*Fiziologia plantelor de cultură*. Întreprinderea Editorial-Poligrafică Ştiinta, Chişinau.

**Chauhan, A. and Joshi P.C.,** (2008): *Effect of ambient air pollution on photosynthetic pigments on some selected trees in urban area*. Ecology Environment and conservations, 14(4), 23-27.

**Davison, A. W. and Blakemore, J.,** (1976): *Effects of air pollution on plants* (Ed.T.A. Mansfield). Cambridge University Press, Bridge, UK: 209.

**Honour, S.L., J.N. Bell, T.W., Ashenden, J.N., Cape and S.A. Power,** (2009*): Responses of herbaceous plants to urban air pollution: Effects on growth, phenology and leaf surface characteristics*. Environ. Pollut., 157: 1279-1286.

**Ivănescu, L., Toma, C.,** (2003):*Influenţa poluării atmosferice asupra structurii plantelor*. Edit. Fundaţiei Andrei Şaguna Constanţa.

**Joshi, N.A. Chauhan and P.C. Joshi,** (2009): *Impact of industrial air pollutants on some biochemical parameters and yield in wheat and mustard plants*. Environmentalist, 29: 398-404.

**Joshi, P.C. and Swami, A.,** (2007): *Physiologigal responses of some tree species under roadside automobile pollution stress around city of Haridwar, India*. Environmentalist, 27: 365-374.

**Liu, Y.J. and Ding, H.,** (2008):*Variation in air pollution tolerance index of plants near a steel factory: Implication for landscape-plant species selection for industrial areas*. Wseas Trans. Environ. Dev., 4: 24-32.

**Mackinney, G.,** (1941): *Absorption of light by Chlorophyll solutions*. J. Biol. Chem. 140: 315-319.

**Mandal, M.,** (2000):*Physiological changes in certain test plants under automobile exhaust pollution*. Journal of Environment Biology. 22(1): 43-47.

**Tiwari, S., Agrawal, M., Marshall, F.,** (2006): *Evaluation of ambient air pollution impact on carrot plants at a suburban site using open top chamber*. Environmental Monitoring and Assessment 266, 15-30.
**Woo, S.Y., D.K. Lee and Y.K. Lee,** (2007): *Net photosynthetic rate, ascorbate peroxidase and glutathione reductase activities of Erythrina orientalis in polluted and non-polluted areas*. Photosynthetica, 45: 293-295.
**Tomašević, M., Aničić, M.,** (2010) *Trace element content in urban tree leaves and SEM-EDAX characterization of deposited particles* Chemistry and Technology 8: 1-13.

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