ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 18, No. 3 2011

Katarzyna MALINOWSKA[1]

CONTENT OF ASSIMILATION PIGMENTS IN THE PHOTOSYNTHECTIC APPARATUS OF MAPLE (*Acer platanoides* L.) GROWING IN VARIOUS SITE CONDITIONS OF SZCZECIN

ZAWARTOŚĆ BARWNIKÓW ASYMILACYJNYCH W APARACIE FOTOSYNTETYCZNYM KLONU ZWYCZAJNEGO (*Acer platanoides* L.) ROSNĄCEGO W RÓŻNYCH WARUNKACH SIEDLISKOWYCH SZCZECINA

Abstract: The present study shows the results of the research work on the content of assimilation dyes in the leaves of *Acer platanoides* L., growing in different site conditions in Szczecin. The variance analysis showed a significant influence of the site and the date on the content of the studied physiological parameters. Lower amounts of chlorophyll and carotenoids were obtained in the leaves of trees growing along the street of high volume of traffic. On the basis of the correlation coefficient, a significant negative correlational relationship was recorded between the concentration of Cd, Pb, Fe and Cu in the leaves and the content of chlorophyll *a* and *b* in the leaves of *Acer platanoides.*

Keywords: assimilation pigments, *Acer platanoides* L.

Trees that constitute one of the most important elements of urban green sites are exposed to several stresses concurrently. The main stressful factor are just vegetation conditions in large agglomerations [1, 2]. The degree of plant pollution depends to a large extent on a current emission of pollutants rather than their concentration in soil [1, 3, 4]. The plant dye system is very sensitive to the effect of individual trace metals and gas impurities resulting, among other things, in disorders of the chlorophyll synthesis and their function of capturing photons [5–8].

The results presented in this paper constitute a fragment of multidirectional studies the aim of which is to determine the physiological activity of trees and to prove the

[1] Departament of Plant Physiology, Westpomeranian Technological University in Szczecin, ul. J. Słowackiego 17, 71–434 Szczecin, Poland, phone: +48 91 449 63 82, email: katarzyna.malinowska@zut.edu.pl

usefulness of the examined physiological parameters for the assessment of the degradation degree of urban habitats of Szczecin.

The aim of the study was to determine the amount of assimilation pigments in the leaves of maple growing in the agglomeration of Szczecin and the usefulness of the studied physiological parameters for the assessment of the degradation degree of the environment in Szczecin.

Material and methods

The studies were carried out in the area of Szczecin in two consecutive years (2003–2004) during the period of trees vegetation. Measurement sites were situated along the streets of heavy traffic, in the parks and the control point about 25 km from the city. While selecting research sites, the age of trees and the location of the control points of the Provincial Inspectorate of Environmental Protection (WIOS) were taken into consideration, in which the state of the air pollution in Szczecin is recorded. On each research site, four representative trees were selected. A few one year old shoots from each tree were designated for the studies. The material for the analysis was based on fully formed leaves of the first and the second pair of the year's gain of *Acer platanoides* L. The content of assimilation pigments (chlorophyll *a*, *b* and carotenoids) in the leaves were studied four times during vegetation, according to Lichtenthaler and Wellburm [9].

Table 1 shows the results concerning the level of air pollution in the area of Szczecin, selected from the measurement points of the Provincial Inspectorate of Environmental Protection. The results of average annual measurements of SO_2 in 2003–2004 were differentiated depending on the localization of the control point, but in no control point the allowable value of 20 $\mu g \cdot m^{-3}$ was exceeded. The content of NO_2 in the air was fairly high and both in 2003 and in 2004 the level of pollution with NO_2 exceeded the maximum average annual concentration [10].

Table 1

The air pollution with SO_2 and NO_2 [$\mu g \cdot m^{-3}$] in the area of Szczecin

Pollution measurements site	2003				2004			
	Pollution during the vegetation period		Average annual pollution		Pollution during the vegetation period		Average annual pollution	
	SO_2	NO_2	SO_2	NO_2	SO_2	NO_2	SO_2	NO_2
Św. Łukasza street	5.6	18.3	11.1	21.5	4.2	16.4	7.1	20.6
A. Struga street	5.9	29.9	10.4	32.8	2.4	27.1	6.8	31.0
Wyzwolenia street	b.d.	b.d.	b.d.	b.d.	1.8	16.6	5.3	21.4
Brama Portowa	4.3	43.8	11.6	40.8	2.7	30.8	8.3	36.6

b.d. – lack of data. The allowable value of SO_2 D_a – 20 $\mu g \cdot m^{-3}$ (maximum allowable average annual concentration); of NO_2 D_a – 30 $\mu g \cdot m^{-3}$ (maximum allowable average annual concentration).

Results and discussion

On the basis of the variance analysis it was found that a research site had a significant effect on the content of assimilation pigments in the leaves of maple. The studies showed that the leaves of trees growing along a street of heavy traffic were marked by the significantly smallest content of assimilation pigments. In the assimilation apparatus of trees on these sites an average content of total chlorophyll amounted to 66.2 % in 2003 and in 2004 69.8 % of average value of this dye in the leaves of control trees (Fig. 1).

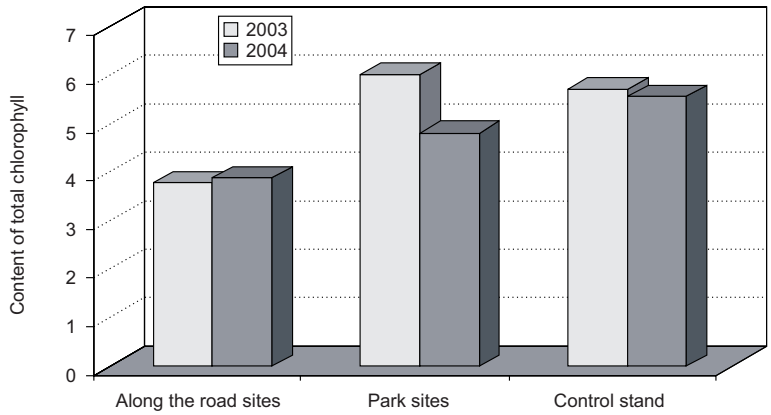

Fig. 1. The average content of total chlorophyll [mg · g^{-1} fresh mass] in the leaves of maple in the area of Szczecin

Significantly less chlorophyll *a* and *b* was observed in September than during a full period of vegetation (Tables 2, 3). The content of chlorophyll *a* in the leaves of trees growing on individual sites was diversified and in 2003 its smallest values were recorded in St. Lukasza street – average: 2.12 mg · g^{-1} of fresh mass, and in 2004 in A. Struga street – average: 2.59 mg · g^{-1} of fresh mass (Table 2). Average values of this dye in these points were lower by 1.92 mg · g^{-1} of fresh matter in 2003 and by 1.45 mg · g^{-1} of fresh mass in 2004 than in the leaves of control trees (Table 2). The average content of chlorophyll in the leaves of trees growing on sites of diverse traffic in 2003–2004 was similar and it amounted to about 1.04 mg · g^{-1} of fresh mass. The content of this dye in the leaves from these research sites was lower by 0.5 mg · g^{-1} of fresh matter than in the control trees (Table 3). Approximate values of the chlorophyll *b* content were observed in the leaves of control trees in both years (on average 1.52 mg · g^{-1} of fresh mass), (Table 3). It was also shown that the content of chlorophyll *b* in the leaves of the examined trees was on average twice as small as that of chlorophyll *a* [11–13]. Lower values of the studied physiological indicators in the leaves growing in the city centre result probably, among other things, from gas and dust impurities of the air. Measurements conducted by the Provincial Inspectorate of Environmental Protection showed that the concentration of SO_2 during the vegetation period was

Table 2

The content of chlorophyll *a* [mg · g^{-1} fresh mass] in the leaves of maple in relation to the site and the date of the studies

Factor I – Stand	Factor II – Date								
	2003				2004				
	VI	VII	IX	The avenage of factor I	VI	VII	VIII	IX	The avenage of factor I
A. Struga street	3.29	3.26	2.70	3.08	2.95	2.63	2.67	2.12	2.59
Wyzwolenia street	3.27	3.49	3.14	3.30	3.44	3.21	3.15	2.96	3.19
Szosa Stargardzka	3.46	2.25	2.06	2.59	3.12	2.65	2.70	2.43	2.72
Św. Łukasza street	2.24	2.14	1.99	2.12	3.36	2.95	2.86	2.12	2.82
E. Orzeszkowej street	3.45	3.34	2.23	3.01	3.03	3.15	3.11	2.56	2.96
S. Dubois street	2.42	2.42	1.86	2.23	3.17	3.28	2.98	2.49	2.98
Park J. Kasprowicza	3.81	4.06	3.23	3.70	3.91	3.51	3.48	3.15	3.51
Park S. Żeromskiego	4.85	5.57	4.30	4.90	3.72	3.46	3.52	3.24	3.48
Control stand	4.20	4.14	3.78	4.04	4.66	3.98	3.96	3.58	4.02
The average of factor II	3.44	3.41	2.81		3.48	3.20	3.16	2.73	
$LSD_{0.05}$ for	factor I – 0.77, factor II – 0.34, Interaction I×II – n.s., Interaction II×I – n.s.				factor I – 0.69, factor II – 0.28, Interaction I×II – n.s., Interaction II×I – n.s.				

n.s. – non-significant.

Table 3

The content of chlorophyll *b* [mg · g^{-1} fresh mass] in the leaves of maple in relation to the site and the date of the studies

Factor I – Stand	Factor II – Date								
	2003				2004				
	VI	VII	IX	The avenage of factor I	VI	VII	VIII	IX	The avenage of factor I
A. Struga street	1.20	1.04	0.75	0.99	0.98	1.08	0.96	0.87	0.97
Wyzwolenia street	1.33	1.00	0.91	1.08	1.24	1.15	1.21	0.89	1.12
Szosa Stargardzka	1.47	1.70	0.96	1.38	1.04	0.91	0.86	0.68	0.87
Św. Łukasza street	0.92	0.87	0.76	0.85	1.12	0.98	1.05	1.03	1.04
E. Orzeszkowej street	1.01	1.29	0.98	1.09	1.25	1.03	1.15	1.10	1.13
S. Dubois street	1.03	0.92	0.82	0.92	0.96	0.92	1.03	0.91	0.95
Park J. Kasprowicza	1.87	1.83	1.26	1.65	1.53	1.23	1.28	1.12	1.29
Park S. Żeromskiego	2.05	1.81	1.46	1.77	1.49	1.31	1.40	1.19	1.35
Control stand	1.70	1.91	0.94	1.52	1.76	1.48	1.56	1.28	1.51
The average of factor II	1.40	1.38	0.98		1.26	1.12	1.17	1.01	
$LSD_{0.05}$ for	factor I – 0.51, factor II – 0.22, Interaction I×II – n.s., Interaction II×I – n.s.				factor I – 0.43, factor II – 0.19, Interaction I×II – n.s., Interaction II×I – n.s.				

n.s. – non-significant.

Table 4

The content of carotenoids [mg · g $^{-1}$ fresh mass] in the leaves of maple in relation to the site and the date of the studies

Factor I – Stand	Factor II – Date								
	2003				2004				
	VI	VII	IX	The avenage of factor I	VI	VII	VIII	IX	The avenage of factor I
A. Struga street	1.29	1.29	0.84	1.14	0.79	0.65	0.65	0.71	0.70
Wyzwolenia street	1.31	1.35	0.97	1.21	0.71	0.69	0.67	0.69	0.69
Szosa Stargardzka	1.42	1.17	0.94	1.18	0.47	0.51	0.52	0.68	0.54
Św. Łukasza street	0.87	0.93	0.89	0.90	0.77	0.78	0.71	0.85	0.78
E. Orzeszkowej street	1.18	1.05	0.85	1.03	0.58	0.62	0.61	0.62	0.61
S. Dubois street	1.00	0.89	0.83	0.90	0.74	0.79	0.72	0.75	0.75
Park J. Kasprowicza	1.88	1.81	1.63	1.77	0.98	0.99	1.02	1.05	1.01
Park S. Żeromskiego	1.42	1.17	0.94	1.18	0.87	1.02	1.00	1.18	1.02
Control stand	1.58	1.65	0.73	1.32	1.12	1.15	1.11	1.21	1.15
The average of factor II	1.35	1.30	0.99		0.78	0.80	0.78	0.86	
$LSD_{0.05}$ for	factor I – 0.27, factor II – 0.12, Interaction I×II – 0.46 Interaction II×I –0.35				factor I – 0.29, factor II – 0.14, Interaction I×II – 0.32, Interaction II×I – 0.28				

highest on sites along St. Łukasza and A. Struga streets (Table 1). The dye system is very sensitive to the effect of SO_2 and that of individual heavy metals. Both SO_2 and heavy metals non-used in metabolism of plants (Cd and Pb) cause disorders in the biosynthesis of chlorophyll and in their function of capturing photons [14, 15]. In the point situated in the street of heavy traffic and near the traffic lights (A. Struga street) a low amount of chlorophyll *a* and *b* was observed in the leaves of maple in both years of the studies (Tables 2, 3). The measurements carried out by he Provincial Inspectorate of Environmental Protection showed that the level of the NO_2 concentration in this point was high and during the vegetation period it amounted to above 90 % of D_a (maximum allowable average annual concentration). Also the average content of carotenoids in the leaves of the street trees was lowest and in 2003 it amounted on average to 1.06 mg $\cdot$ g^{-1} fresh mass and in 2004 to 0.68 mg $\cdot$ g^{-1} of fresh mass and this constitutes, respectively 80 % and 59 % of its average content in the control leaves (Table 4). Lower amounts of carotenoids in the leaves of the trees growing near throughways were obtained by Lorenc-Plucinska [14]. Also lower contents of carotenoids in the leaves of the trees growing in the city centre were observed by Malinowska [11, 12]. On the basis of the correlation coefficient value, a significant correlational relationship was observed between the content of assimilation dyes and the concentration of heavy metals. The concentration of lead, cadmium, iron and copper had a significant negative effect on the content of chlorophyll *a* and *b*, whereas it had a non-significant negative effect on the content of carotenoids (Table 5).

Table 5

Coefficient of correlation between heavy metal concentration and assimilation pigments content in the leaves of maple

Chemical element	Assimilation pigments					
	2003			2004		
	Chlorophyll *a*	Chlorophyll *b*	Carotenoids	Chlorophyll *a*	Chlorophyll *b*	Carotenoids
Lead	–0.72*	–0.78*	–0.53	–0.87*	–0.79*	–0.66
Cadmium	–0.75*	–0.73*	–0.53	–0.86*	–0.81*	–0.79*
Iron	–0.57	–0.72*	–0.50	–0.80*	–0.76*	–0.57
Copper	–0.79*	–0.75*	–0.71*	–0.81*	–0.75*	–0.70*
Cobalt	–0.40	–0.57	–0.22	–0.69	–0.56	–0.43

* A significant effect of the factor. Significant differences at the level of $\alpha = 0.05$.

Conclusions

1. A significant negative correlational relationship was shown between the concentration of Pb, Cd, Fe and Cu in the leaves and the content of chlorophyll *a* and *b* in the leaves of *Acer platanoides*.

2. The significance of differences in the content of assimilation pigments in the leaves of the trees was shown in relation to the site and the date of the studies.

3. The studied physiological parameters can be useful for the assessment of the environment degradation in Szczecin.

References

[1] Anderson S., Chappelka A.H., Flynn K. and Odom J.W.: Water Air Soil Pollut. 2000, **118**, 1–11.
[2] Greszta J. and Panek E.: Życie drzew w skażonym środowisku. PWN, Warszawa, 1989.
[3] Bell J.N.B. and Treshow M.: Zanieczyszczenia powietrza a życie roślin. WNT, Warszawa 2004.
[4] Farmer A. [in:]: Zanieczyszczenia powietrza a życie roślin, Bell J.N.B. and Treshow M. (eds.). WNT, Warszawa 2004, 209–220.
[5] Woźny A. and Przybył K. (eds.): Komórki roślinne w warunkach stresu. Wyd. Nauk. UAM, Poznań 2004.
[6] Woźny A. and Krzesłowska M: Idee Ekol.1994, **4**(3), 135–140.
[7] Prasad M.N.V. and Hagemeyer J. (eds.): Heavy metal stress in Plant. From Molecules to Ecosystems. Springer-Verlag, Berlin–Heidelberg–New York 1999.
[8] Rabe R. and Kreeb K.H.: *Bioindication o fair pollution by chlorophyll destruction in plant leaves*. Oikos 1980, **34**, 163–167.
[9] Lichtenthaler H.K. and Wellburn A.R.: *Determinations of total carotenoids and chlorophyll a and b of leaf extracts in different solvents*. Biochem. Soc. Trans. 1983, **11**, 591–592.
[10] Raport o stanie środowiska w województwie zachodniopomorskim w latach 2002–2003 i 2004–2005, WIOŚ, Szczecin 2006.
[11] Malinowska K. and Marska B.: Ecol. Chem. Eng. 2005, **12**(12), 1381–1385.
[12] Malinowska K.: Ecol. Chem. Eng. 2006, **13**(6), 547–552.
[13] Czarnowski M.: Wiad. Botan. 1984, **28**(1), 9–26.
[14] Lorenc-Plucińska G. and Byczyska A.: Ekofizjologiczne aspekty reakcji roślin na działanie czynników stresowych. Uniwersytet Rolniczy im. Hugona Kołłątaja, Kraków 1997.
[15] Woźny A.: Ołów w komórkach roślinnych. Wyd. Sorus, Poznań 1995.

ZAWARTOŚĆ BARWNIKÓW ASYMILACYJNYCH W APARACIE FOTOSYNTETYCZNYM KLONU ZWYCZAJNEGO (*Acer platanoides* L.) ROSNĄCEGO W RÓŻNYCH WARUNKACH SIEDLISKOWYCH SZCZECINA

Zakład Fizjologii Roślin
Zachodniopomorski Uniwersytet Technologiczny w Szczecinie

Abstrakt: W pracy przedstawiono wyniki badań zawartości barwników asymilacyjnych w liściach *Acer platanoides* L., rosnącego w różnych warunkach siedliskowych Szczecina. Analiza wariancji wykazała istotny wpływ stanowiska i terminu na zawartość badanych parametrów fizjologicznych. Obniżone zawartości chlorofilu i karotenoidów uzyskano w liściach drzew rosnących przy ulicy o dużym natężeniu ruchu samochodowego. Na podstawie wartości współczynnika korelacji stwierdzono ujemną istotną zależność korelacyjną pomiędzy koncentracją Cd, Pb, Fe i Cu w liściach a zawartością chlorofilu *a* i *b* w liściach *Acer platanoides.*

Słowa kluczowe: barwniki asymilacyjne, *Acer platanoides* L.