

Relationship between photosynthetic efficiency and total carotenoids and the content of Zn and Sr in *Aesculus hippocastanum* L.

Marija Matić*, Dragana Pavlović, Ksenija Jakovljević, Olga Kostić, Natalija Radulović, Miroslava Mitrović, Pavle Pavlović

Department of Ecology, Institute for Biological Research „Siniša Stanković“ – National Institute of the Republic of Serbia, University of Belgrade, Bulevar Despota Stefana 142, 11108 Belgrade, Serbia

https://doi.org/10.65614/uisk_yucorr.2025.26.ch16

*marija.pavlovic@ibiss.bg.ac.rs

Abstract

Aesculus hippocastanum L., known as the European horse chestnut, is a deciduous tree naturally occurring in the mountainous regions of the Balkans and southeastern Europe, at altitudes between 700 and 1200 meters. Although it adapts well to different growing conditions, its resistance to pollution is limited, resulting in visible damage in urban environments and a decline in natural populations due to disease and environmental stress. Given its widespread occurrence, frequent planting, and the ease of monitoring physiological parameters, *A. hippocastanum* is often used as a bioindicator of pollution, particularly in urban environments. In this study, the influence of Zn, a cofactor of numerous enzymes involved in carotenoid and antioxidant synthesis, and Sr^{2+} , a chemical analog of Ca^{2+} that can interfere with thylakoid membrane stability and PSII enzyme function, was investigated for their effects on photosynthetic efficiency and total carotenoid content at a polluted - Pionirski Park, Belgrade and an unpolluted site – Kosmaj. The leaf samples were analysed using ICP-OES for Mn and Zn, chlorophyll fluorometry for photosynthetic efficiency (Fv/Fm), and spectrophotometry for total carotenoid content. The results showed that Sr concentrations at both sites exceeded levels considered toxic for plant tissues ($>30 \text{ mg kg}^{-1}$; Shacklette et al., 1978), measuring 37.17 mg kg^{-1} at Belgrade and significantly higher at Kosmaj (62.41 mg kg^{-1}). In contrast, Zn concentrations were below the threshold required for normal physiological functioning of plants ($<20 \text{ mg kg}^{-1}$; Kabata-Pendias and Pendias, 2001), with values of only 11.81 mg kg^{-1} in *A. hippocastanum* leaves at both Belgrade and Kosmaj. Consequently, photosynthetic efficiency values were lower than optimal at both sites—0.671 in Pionirski Park and 0.692 at Kosmaj, as well as the total carotenoid content (1.59 mg g^{-1} and 1.87 mg g^{-1} , respectively), probably due to the combined effects of toxic Sr concentrations, which can disrupt thylakoid membrane integrity and PSII activity, and Zn deficiency, which impairs antioxidant defence and enhances oxidative pigment degradation.

The results confirm that *A. hippocastanum* responds to Zn deficiency and toxic Sr accumulation through reduced photosynthetic efficiency and lower carotenoid content, indicating sensitivity to both micronutrient imbalance and excess metal exposure. This highlights its potential as a reliable bioindicator for assessing the impact of trace element availability in different environments.

Keywords: trace elements; *Aesculus hippocastanum*; photosynthetic efficiency; carotenoids; urban pollution; bioindicator

Acknowledgment

This work was supported by the Ministry of Education, Science, and Technological Development of the Republic of Serbia, grant no. 451-03-136/2025-03/200007.