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The effect of hazardous pollutants from coal combustion activity: Phytotoxicity assessment of aqueous soil extracts

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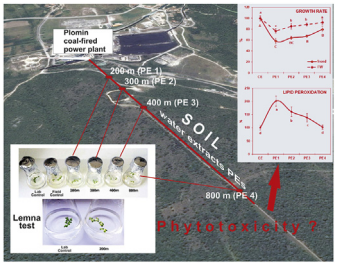
HIGHLIGHTS

- Phytotoxicity of aqueous extracts of coal-contaminated soil was assessed.
- Chemical analysis of aqueous extracts and plants was conducted.
- Toxic components caused growth inhibition and oxidative stress.
- *L. minor* is suitable in evaluation of complex environmental samples.

GRAPHICAL ABSTRACT



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ABSTRACT

Airborne fly ash and related hazardous particles derived from coal combustion contaminate soil and groundwater, negatively affecting ecosystems. The aim of this study was chemical and toxicological evaluation of aqueous extracts of soil collected from the vicinity of a coal-fired Plomin power plant (PPP), using Lemna (*Lemna minor* L.) bioassay and additional biochemical indicators - photosynthetic pigments, lipid peroxidation, antioxidative enzymes and glutathione. Topsoil samples were collected from distances of 200, 300, 400 and 800 m from the PPP in accordance with the prevailing SW wind direction. Elevated levels of polycyclic aromatic hydrocarbons (up to 15,765 ng L^{-1}) and potentially toxic trace elements were detected in the Plomin soil extracts (PEs) in comparison to control soil extract (CE). Trace elements accumulated in *L. minor* were mostly in accordance with their concentrations in PEs. The results demonstrate that PEs induced significant growth inhibition and other phytotoxic effects. Those effects can be related to damage caused by increased production of reactive oxygen species and impaired antioxidant levels. The connection among the phytotoxicity, a distribution of analyzed contaminants, and distances from the PPP is clearly established.

1. Introduction

Coal is the most abundant fossil fuel, supplying some 30–40% of commercial global energy. Its use is likely to increase throughout the world, regardless of the environmental costs (Singh et al., 2015). Namely, the coal combustion results in ash and gas emissions into

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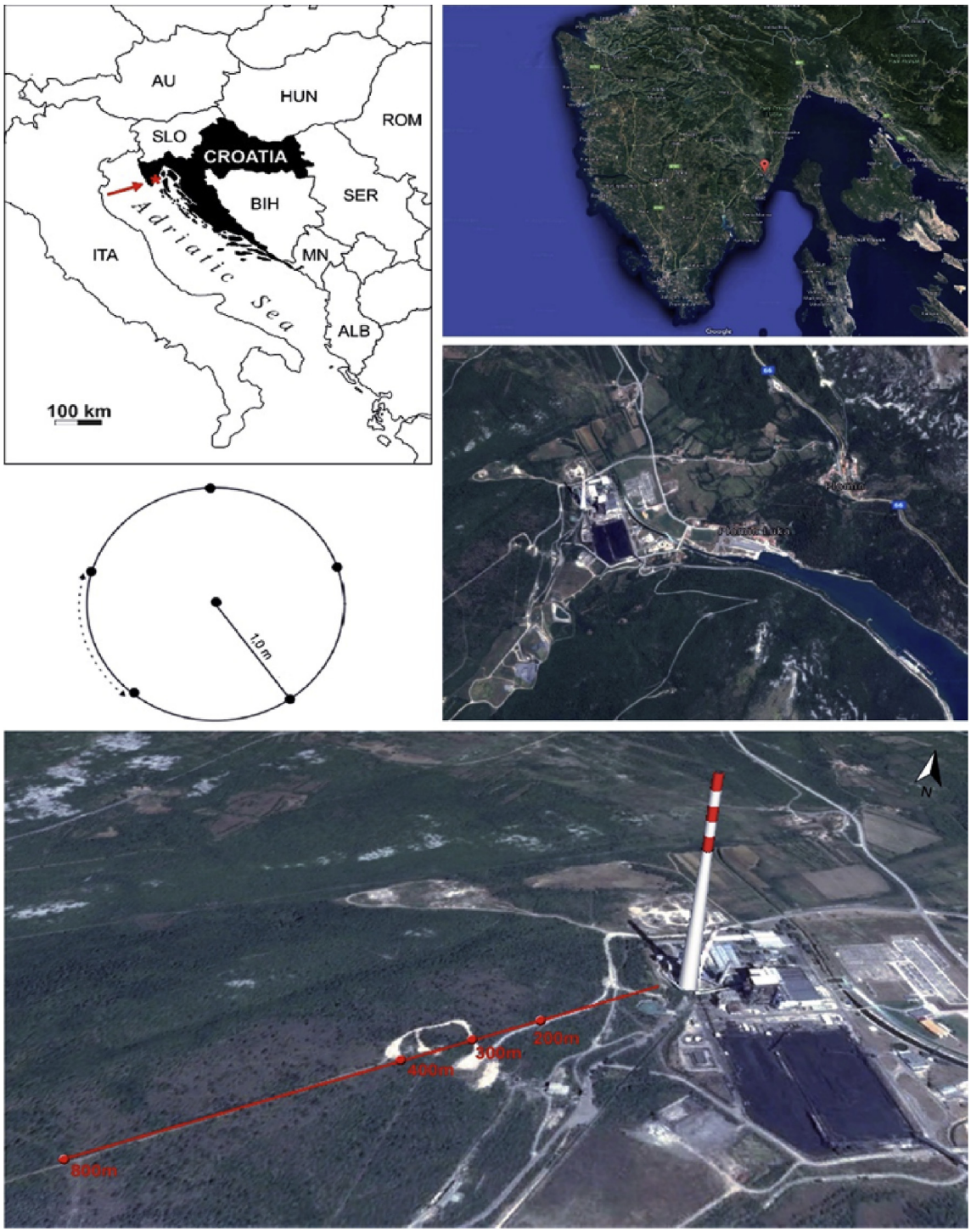

Fig. 1. Map of the study area. From the upper left corner (clockwise): geographical position of the PPP locality; the Istrian Peninsula; the Plomin Bay; soil sampling sites (downwind SW pollution gradient); soil sampling scheme (five sites around a central point, approximately 1 m apart).

the atmosphere (Saikia et al., 2015), where they are washed out by rainfall, and transferred into the soil and surface waters. Coal ash is a solid by-product composed of toxic residues (Mardon and Hower, 2004), mainly potentially toxic trace elements (PTEs, like Cd, Ni, As, etc.) and persistent organic pollutants (e.g. PAHs, polycyclic aromatic hydrocarbons), capable of migration into floral and aquatic matrices, causing them adverse effects (Manzo et al., 2008; Saikia et al., 2016; Awoyemi and Dzantor, 2017). The PPP (Istrian Peninsula, Croatia, Fig. 1) was powered with superhigh-organic-sulphur (SHOS) Raša coal during the period 1970–2000. That coal has been renowned in world terms for its exceptionally high content of sulphur, up to 14% (Medunić et al., 2016a, 2017). Given that the locality is inside the coastal karst environment (Fig. 1), well known for its vulnerability, it is important to evaluate its environmental quality in the context of previous as well as recent exposure to coal and/or ash airborne particles (Frančišković-Bilinski et al.,