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Glutamine Synthetase, Peroxidase and Protease as Indicators of the Ecological State of Higher Aquatic Plants

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Abstract: The contamination of water by heavy metals leads to conditions of ecological tension in the aquatic systems. In this work we consider to use the peroxidase, protease and glutamine synthetase of aquatic higher plants *Typha angustifolia* and *Lemna polórhyza* as indicators of ecological state of the aquatic biocenosis. In response to the 2.5 mg/l lead contamination the glutamine synthetase activity dropped down 10-fold already in 1 hour in the photosynthetic tissues of both plants with following restore up to 70-80% of initial activity values in 3 hours. Also strong inhibition of proteolytic activity without recovery in both *L. Polórhyza* and *T.angustifolia* leaves was detected after the lead introduction. By contrast, the peroxidase did not exhibit high sensitivity to the lead contamination and demonstrated 2-fold decreased activity. Taking together, these data demonstrate the possibility to evaluate the ecological state of higher aquatic plants by measuring the activity of the glutamine synthetase, peroxidase and protease in their photosynthetic tissues.

Key words: Lead contamination · Aquatic plants · Peroxidase · Protease · Glutamine synthetase

INTRODUCTION

In recent years, in many studies the enzymes are used as biomarkers of aquatic stress caused by pollutants [1, 2]. As a markers catalase, glutathione synthase and cytochrome oxidase are widely used. In this paper, we consider as indicators the peroxidase, protease and glutamine synthetase.

Glutamine synthetase (GS; EC 6.3.1.2, L-glutamate: ammonia ligase ADP forming) is a central enzyme of nitrogen flow in plants and catalyzes the ATP-dependent incorporation of ammonium (NH_4^+) to γ-carboxyl group of glutamate by glutamine formation. Ammonium assimilated by GS comes from a variety pathways, including direct revenues from the soil, the reduction of nitrates and nitrites, photorespiration, deamination of phenylalanine and the catabolite release of ammonia during the aging process. GSs are found in photosynthetic and non-photosynthetic tissues of higher plants and are oligomeric isoenzymes that are either in the cytosol or in chloroplasts [3]. In angiosperms, there are two major isoforms of GS, the cytosolic GS (GS1) and GS of chloroplasts (GS2). Ammonium assimilated into glutamine by GS2 in young leaves, is formed mainly due to nitrate reduction and photorespiration [4]. In turn, the cytosolic GS1 forms glutamine for intercellular transport of nitrogen. It assimilates ammonium incoming from the soil and is included in the biosynthesis of phenylpropanoids and remobilization of nitrogen [5, 6]. GS was shown to play an important role in the growth and development of plants [5]. As example, the transgenic poplar, having increased GS activity, have a high rate of vegetative growth [7], increased resistance to drought, oxidative stress as well as increased efficiency of nitrogen use [8]. Thus, the level of activity of GS in plants is the limiting factor in the growth and development.

Peroxidases are the enzymes that catalyze the oxidation of various organic compounds by the oxygen of hydrogen peroxide. Peroxidases are complex proteins and protect cells against reactive oxygen species (ROS). In the presence of H_2O_2, they are able to oxidize various substrates [9]. In higher plants over 40 different genes coding for peroxidases can be found, some isoforms of the enzymes can be produced by posttranslational

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