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Toxicity and removal of heavy metals (cadmium, copper, and zinc) by *Lemna gibba*

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ABSTRACT

Effects of cadmium, copper, and zinc on the aquatic plant *Lemna gibba* were determined under controlled conditions; in parallel their removal from the growth medium was followed. The results showed that the three heavy metals affected growth, a physiological stress index defined as the ratio of Chlorophyll to phaeophytin (D665/D665a), and the contents of proline. After 4 days, 10^{-3}–10^{-1} mg/L Cd inhibited growth by 25–100%, reduced D665/D665a by 35–89%, and increased proline content by 44–567%. Under the same conditions, 10^{-4}–10^{-1} μg/L Cu inhibited growth by 36–75%, reduced D665/D665a by 19–81%, and increased proline content by 67–288%. Comparable concentrations of Zn had little effect. However, higher concentrations (4, 30, and 50 mg/L) inhibited growth by 50–79%. Also, 0.1 and 30 mg/L induced a small reduction of D665/D665a (−3.8% and −22%) and an increase in proline contents (+144% and +177%). When it was observed, proline accumulation was always transient and the maximum was reached after 4 days. Monitoring metal concentration in the medium showed that *L. gibba* was able to remove metals from the medium. Zn and Cu removal was biphasic, it was rapid during the first 2 days (> 60% reduction) and slow (10–20%) during the following 8 days. For Cd, removal was linear and depended on the initial concentration. It reached approximately 90% after 6 or 8 days for initial concentrations of 10^{-1} and 10^{-3} mg/L, respectively.

1. Introduction

One of the major concerns of this century is the preservation of environmental quality. Indeed, release of natural or synthetic substances constitutes one of the most significant factors of degradation of the biosphere. Aquatic ecosystems are directly or indirectly end destinations of these substances, and they often present high pollutant concentrations that may be deleterious for organisms therein.

Among these polluting substances, heavy metals are easily transported and accumulated in the environment. They arrive in aquatic ecosystems as dissolved and solid waste from domestic, industrial, and agricultural runoffs. Many industries, such as automotive, metal-producing, electroplating, battery and electric cable manufacturing, mining, tannery, steel and textile, release heavy metals such as cadmium, copper, chromium, nickel, and lead in wastewaters (Demirezen et al., 2007). In Algeria, metals traces in surface and sea waters originate from industrial activities, namely tanneries and paper mills (Cd, Zn, Cu, Hg, Cr, and Ni), waste water (Zn, Cu, Cd, Pb, and Ni), and also from agriculture by improper use of mineral pesticides (*e.g.* $CuSO_4$ in Bordeaux mixture) (Semsari and Gaid, 1994; Semsari and Ait Amar, 2001). Such contaminations result in high concentrations of heavy metals in plants, sediment, and water, which clearly demonstrate pollution by these metals (Aksoy et al., 2005). These heavy metals may be toxic to aquatic ecosystems and human health, and they also accumulate in organisms. The accumulation of these heavy metals in plants causes physiological and biochemical changes. The use of these modifications as endpoint for the evaluation of toxicity of these pollutants was largely discussed in various organisms (Prasad et al., 2001; Perry et al., 2002; Dhir et al., 2004; Pavlīková et al., 2008). Among these organisms, Lemnacea received much attention from scientists because of their potential accumulation capacity of contaminants. Indeed, *Lemna* sp. was shown to accumulate heavy metals such as Cd, Se, and Cu in their tissues (Zayed et al., 1998; Qian et al., 1999). These plants were therefore used for the evaluation and monitoring of metals in water (Wahaab et al., 1995; Kähkönen and Manninen, 1999; Cardwell et al., 2002). In addition, aquatic plants could be used in phytoremediation to reduce organic matter or remove metallic pollutants from water. (Dunbabin and Bowmer, 1992; Mishra and Tripathi, 2009). Some of this research was conducted using *Lemna* sp. (Miretzky et al., 2004; Noemi et al., 2004; Olette et al., 2008).

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