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Research Paper :

Biosorption of Cd^{2+} from aqueous metal solutions by cyanobacterial biomass

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ABSTRACT

This paper provides information on biosorption of Cd^{2+} by the cyanobacterium *Aulosira fertilissima*. Over all pattern of Cd^{2+} sorption rate seems to be dependent on the level of Cd^{2+} present in the external medium and length of exposure to metal. Cd^{2+} sorption was rapid during first five minutes thereafter the process slowed down and finally reached to saturation. A growth promoting pH (8.0) resulted more Cd^{2+} uptake than pH 6.0 and 10.0.

KEY WORDS : Calcium, Cd^{2+} sorption, Metal, Metal toxicant, *Aulosira fertilissima*

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Metal is an unique class of toxicants since they can not be broken down to non-toxic forms. Environmental contamination by toxic heavy metals, as a function of human activities, is a serious problem due to their biomagnification, accumulation in food chain and continuted persistence in terrestrial and aquatic ecosystem (Chen and Pan, 2005). The metallic ions of the salt carry a positive charge and are attracted to the part when they reach in the negatively charged part, provides the electron to reduce the positively charged ions to metallic form (Gajendra, 1996). Metal ions *viz.* Zn^{2+}, Cu^{2+}, Fe^{2+} etc. are essential micronutrient for plant and animals metabolism but when in excess can become extremely toxic (Tayler *et al.*, 1989).

During recent years different mechanisms are developed for the removal of heavy metals from aqueous solutions. Biosorption techniques employed for metal removal has been found to be highly selective due to passive accumulation in cells and surface binding to various functional groups present on cell wall (Phoenix *et al.*, 2002, Yee *et al.*, 2004). Uptake and accumulation of heavy metals by algae, bacteria, fungi, mosses, macrophytes and higher plants are on record (Ali *et al.*, 1999; Jasmine and Sasikumar, 2006; Michalak *et al.*, 2007; Banarjee *et al.*, 2008; Shanthi and Kumari, 2009; Munir *et al.*, 2010). The metal accumulation by microbes is possible by a rapid binding of cations to negatively charged group on the cell surface and the subsequent metabolism dependent intracellular cation uptake (Singh *et al.*, 2001; Banarjee *et al.*, 2008). Therefore, the present study is most important in assessing the role of naturally occurring cyanobacterium *Aulosira fertilissima* in reducing the toxicity of Cd^{2+} and the role of pH in regulating sorption of heavy metals.

EXPERIMENTAL METHODOLOGY

Aulosira fertilissima, obtained from Biological Research Lab., Department of Botany and Biotech., Kutir P.G. College, Chakkey, Jaunpur (U.P.), India, was cultured in BG-11 medium at pH 8.0 and temperature 28.0±2^{0}C under illumination of 2500-3000 lux cool theorescent light intensity for 14:10 hr light and dark rhythum.

Cd^{2+} sorption experiment:

Exponentially grown cells of *Aulosira fertilissima* from 8 days old stock culture were centrifuged, washed repeatedly with triple glass distilled water and inoculated into 100 ml sterile pre cooled growth medium containing 6-12 mgl^{-1} Cd^{2+} (as $CdCl_2$, Loba Chemicals, India) separately. Cd^{2+} uptake experiments were carried out at 28±2^{0}C. Algal samples were withdrawn and centrifuged to recover the cell pellet. The repeatedly washed pellet was dried and added to 1 ml HNO_3 : HClO mixture (10 : 1 v/v) ensure digestion and release of associated metal ions in a boiling water bath for 30 min. After sufficient cooling such samples were diluted to a total volume of 5ml with triple glass distilled water. A further centrifugation removed any undigested material and resulting supernatant was analyzed for Cd^{2+} level by Atomic Absorption Spectrophotometer and level was expressed in mg g^{-1} biomass. Different pH was maintained 6.0, 8.0 and 10.0 by adding 0.1N NaOH or HCl.

EXPERIMENTAL FINDINGS AND ANALYSIS

The sorption of Cd^{2+} by cyanobacterium *Aulosira fertilissima* at 6, 10 and 12 mg l^{-1} initial concentration over a period of 2hrs, from the nutrient medium is given in Fig.1. The over all pattern of Cd^{2+} sorption rate seems to be dependent on the level of Cd^{2+} present in the external medium. Present observation demonstrated that the sorption of Cd^{2+} was rapid during first five minutes to all the three Cd^{2+} level (*i.e.* 6, 10, 12 mg.l^{-1}) used. Thereafter, the process slowed down and reached to saturation. The time required to reach saturation for Cd^{2+} was 60 min at their tested initial concentration. The sorption of Cd^{2+} was lowest 2.0 mg g^{-1} biomass at 6 mg l^{-1} concentration and highest (38.0 mg g^{-1} biomass from 12 mg l^{-1} of Cd^{2+}.

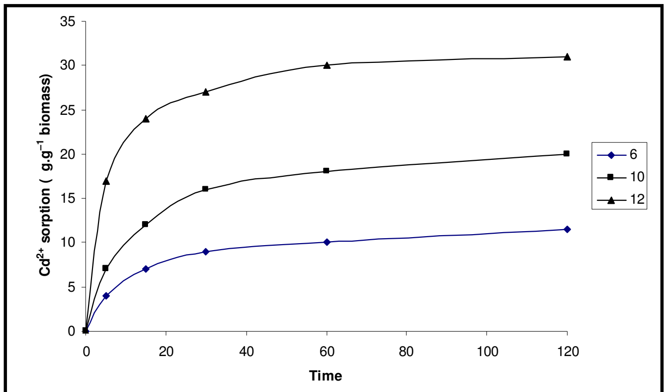

Fig. 1 : Cadmium (Cd^{2+}) sorption by *A. fertilissima* as a function of time from the medium containing 6, 10 and 12 mg l^{-1} Cd^{2+}

The effects of pH on Cd^{2+} sorption at 12 mg l^{-1} are summarized in Fig. 2. The sorption pattern at different pH (6.0, 8.0 and 10.0) showed that pH 8.0 (pH supporting optimal growth of the organism) favoured maximum sorption (40 mg.g^{-1} biomass) after 120 min. A higher pH at level 10 neither supported more Cd^{2+} uptake nor favoured better growth of the test organism. Thus, Cd^{2+} uptake being maximum at pH 8.0 followed by pH 10 and lowest uptake at pH 6.0 (4.0 mg g^{-1} biomass).

The present observations indicated that metal sorption was very efficient in first few minutes of the process. This might be due to the availability of active sites around the cell wall or inside the cell wall. The sorption pattern of Cd^{2+} is similar to other micro-organisms. Accumulation of Cd^{2+} and Co^{2+} in cells of *Saccharoyces cerevisiae* was found due to (a) the metabolism independent leading to cation binding on to the cell surface (b) the metabolism dependent cellular uptake (Norris and Kelley, 1977). In the second stage with the gradual occupancy of active sites, the sorption became less efficient (da Costa and Leite, 1972; Garnham *et al.*, 1992; Singh *et al.*, 2001). The extent of Cd^{2+} sorption being max at pH 8.0 followed by pH 10 and 6.0 may be correlated with growth of the cyanobacterium as growth promoting pH supported more Cd^{2+} uptake. The present observations have demonstrated the possible utilization of *Aulosira fertilissima* biomass for sorption of Cd^{2+} enriched feed additives by modifying pH of the medium and metal concentration.

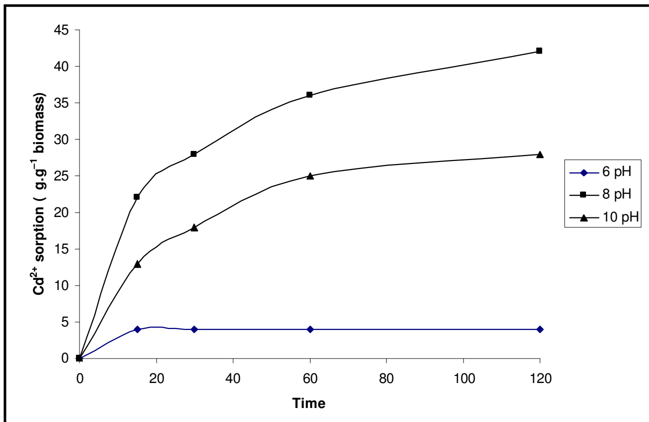

Fig. 2 : Effect of pH on Cd^{2+} sorption by cyanobacterium *A. fertilissima* at different time intervals

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