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BIOSORPTION OF CADMIUM FROM AQUEOUS MEDIUM BY CYANOBACTERIUM *NOSTOC CARNEUM* AGARDH

LATIKA SHARAN[1], BHARTI RAIPAT*, AND M.P. SINHA
Department of Zoology, Ranchi University, Ranchi - 834 008
*Department of Zoology, St. Xavier's College, Ranchi - 834 001
[1]Department of Botany, Ranchi Women's College, Ranchi - 834 001
E-mail: m_psinha@yahoo.com

ABSTRACT

Pure strain of *Nostoc carneum* Agardh cultured in BG II medium under continuous white light (2000 lux) and at 25±2^{0}C temperature was used for removal of cadmium in aqueous solution. The results showed q_{max} value of *Nostoc carneum* for cadmium adsorption to be 2860 mg/g dry weight .The equilibrium of adsorption was attained at 8th hour of innoculation. The paper deals with the adsorptive capability of *Nostoc carneum* aimed at its use as an agent of heavy metal removal from natural habitat.

KEY WORDS
Adsorption
Nostoc carneum
Cadmium
Cyanobacteria

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***Corresponding author**

INTRODUCTION

The advances in technology have sustained our industrialized society. During the twentieth century, the explosive development of chemical industries has produced a bewildering variety of chemical compounds that have led to the modernization of our lifestyles on one hand while on the other polluted the environment to an alarming scale (Iwamoto and Nasu, 2001). The large-scale production of a variety of chemical compounds, however, has caused global deterioration of environmental quality.

The pollution of the natural environment by heavy metals has become a serious problem not only in industrialized countries but also in developing countries in Southeast Asia. Biosorption for the removal of heavy metals has received increasing attention in recent years and various biomaterials, such as bacteria, fungi, yeasts, and other plants have been employed to investigate effective biosorption systems (Shuttleworth and Unz, 1993; Holan and Volesky, 1995; Volesky and Holan, 1995; Kotrba and Ruml, 2000; Nedelkoska and Doran, 2000; Nagase *et al.,* 2005).

Studies have been done on biosorption using cyanobacteria to develop a heavy metal removal system applicable in tropical countries, because the photoautotrophic growth under oligotrophic conditions of cyanobacteria allows for outdoor mass cultivation at a low cost in a tropical environment. Many cyanobacterial strains in like *Tolypothrix tenuis, Cyanospira capsulata, Nostoc* PCC 7936 in different countries have showen the heavy metal removal ability (Inthorn *et al.,* 1996, Nagase *et al*., 1997; Zakaria , 2001; *Micheletti et al.,* 2008).

The present communication deals with the efficacy of cadmium sorptive capability of a capsulated exopolysaccharide producing cyanobacterium *Nostoc carneum* Agardh in laboratory conditions.

MATERIALS AND METHODS

Biomaterials: Pure strain of *Nostoc carneum* Agardh was obtained from School of Life Sciences, Sambalpur Univetsity, Sambalpur and cultured in BG II medium (Stanier *et al.,* (1997). The cyanobacterial culture was maintained under continuous white light (2200 lux) at the temperature 25 ± 2^0 C. under aseptic condition. The culture flasks were subjected to hand shaking intermittently.

Culture medium of cyanobacterium: The culture medium was composed of

0.04g $K_2H\ PO_4.3H_2O$; 0.075g $MgSO_4.7H_2O$; 0.036g $CaCl_2.\ 2H_2O$; 0.006g Critic acid; 0.006g Ferric ammonium citrate; 0.001g EDTA (Disodium magnesium salt); 0.02g Na_2CO_3; 2.86g H_3BO_3; 1.81g $MnCl_2.4H_2O$; 0.222g $ZnSO_4.7H_2O$; 0.049g $CO(NO_3)_2.6H_2O$; 0.39g $Na_2MoO_4.2H_2O$; 0.079g $CuSO_4.5H_2O$ and trace element dissolved in 1000 mL of distilled water. The pH was kept at 7.4. Before the inoculation, the culture medium was subjected to autoclaving for sterilization.

Experimental setup: Conical flasks of size 250 mL were used for the experiment.Four sets of flasks each with four replicates containing 50 mL of basal nutritional media (BNM) were taken. To each flask 2 mL of the *N. carneum* culture was introduced. One set of inoculated flask (four flasks) was kept as control. To the other three sets 0.5 ppm of cadmium chloride ($CdCl_2$) was introduced. All the conical flasks were maintained at the temperature 25 $\pm$ 2^0 C under continuous white light (2200 lux). The flasks were sterilized before using them for culture.

Heavy metal estimation: The samples were digested in acid mixture and analysed by atomic absorption spectroscope (model no: ECL AAS 4219) for estimation of heavy metal. Estimation was done at an interval of two hours, up to 18^{th} of exposure.

RESULTS AND DISCUSSION

Sorption of cadmium by the cyanobacterium – *Nostoc carneum* was observed to be different at different intervals. After two hours of inoculation and the onset of the experiment the cadmium uptake was 480 µg/g dry weight of cyanobacteria. After four hours it was found to be 1690 µg/g which increased to 2130 µg/g and 2860 µg/g at 6^{th} and 8^{th} hours of experiment. 2860 µg/g was the highest uptake of cadmium by *Nostoc carneum* which there after declined gradually and it was 2520 µg/g at 18^{th} hour *i.e.* at the end of the experiment. The experimental results reveal that the uptake of cadmium is very high during the initial exposure period and also that it reached a saturation

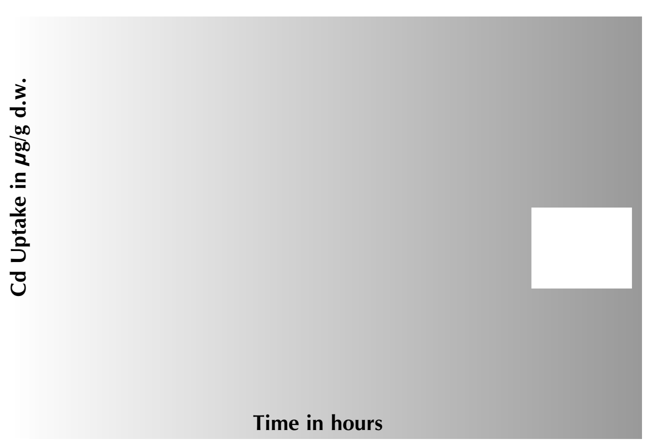

Figure 1: Uptake and accumulation of Cd by *Nostoc carneum*

point (in this case at the 8^{th} hour after innoculation) and there after a decline started. (Fig. 1)

Heavy metals, depending on their oxidation states, can be highly reactive and, as a consequence, toxic to most organisms. The effect of heavy metals appears to be related to production of reactive oxygen species (ROS) and the resulting unbalanced cellular redox status. Algae respond to heavy metals by induction of several antioxidants, including diverse enzymes such as superoxide dismutase, catalase, glutathione peroxidase and ascorbate peroxidase, and the synthesis of low molecular weight compounds such as carotenoids and glutathione (Ernani Pinnto *et al.*, 2003; Kanuert and Knauer 2008). At high, or acute, levels of metal pollutants, damage to algal cells occurs because ROS levels exceed the capacity of the cell to cope. At lower, or chronic, levels algae accumulate heavy metals and can pass them on to organisms of other trophic levels such as mollusks, crustaceans, and fishes, we review here the evidence linking metal accumulation, cellular toxicity, and the generation of ROS in aquatic environments.

In case of capsulated exopolysaccharide producing cyanobacteria like *Nostoc carneum* the role of capsular polysaccharide becomes very important in imparting the heavy metal removal or sorption capability to the species.The role of the capsular exopolysaccharide, the main constituents of the cyanobacterial envelope, in binding heavy metal like cadmium has been studied by De Philippis *et al.*, (2003). They reported that the polysaccharide extracts of these organisms absorbed high amounts of Cd^{2+} (115 – 425 μg mg^{-1}).

De Philippis *et al.*, (2003) studied two capsulated exopolysaccharides producing cyanobacteria *Cyanospira capsulate* and *Nostoc* PCC 7936 with regard to their metal removal capability and found that q_{max} (maximum amount of Cu removal per unit biomass) 96 $\pm$ 2 mg Cu (II) for *C. capsulata* and 79 $\pm$ 3 mg for *Nostoc* PCC 7936. The experimental data best fit with the Langmuir sorption isotherm. In the present study the q max value for *Nostoc carneum* with regard to Cd^{2+} removal in experimental setup has been found to be 2860 μg/g dry weight of the species at the 8^{th} hour of inoculation.

The two hourly estimation of heavy metal sorption during the present study showed that maximum sorption of Cd^{2+} by *Nostoc carneum* was done at 8^{th} hour of the inoculation. The sorption of heavy metal has been reported to start from the time of contact till the time of attainment of equilibrium state which is metal dependent (De Philippis, 2003) In case of Cu sorption by *Nostoc* PCC 7936 the 6^{th} hour was time of maximum sorption. The delayed time of maximum sorption in the present study might be due to specific features of the metal or species concerned or due to the chemical characteristics of medium in the flasks which contained high amount of Ca^{2+} and Mg^{2+} received from culture medium. The presence of Mg^{2+} and Ca^{2+} has been reported to influence the metal removal capability adversely of cyanobacteria species reducing metal adsorption up to 60 to 70% (De Philippis,*et al.,* 2003).

Micheletti e*t al.,* (2008) reported that *Nostoc* PCC 7936 strain showed greater sorptive capacity for Cu which suggests its use aimed at recovering this metal from multiple – metal solution. Though no such experiment has been done for the species but it appears that *Nostoc carneum* has sufficiently high capability to remove Cd from surroundings and hence can be used safely for Cd removal from contaminated habitats as it is a nontoxic species.

Zakaria (2001) reported that the chlorophyll *a* content of *G. magna* during sorption of Cd^{2+} and Mn^{2+} in living cells was not influenced by heavy metal concentration indicating that both Cd^{2+} and Mn^{2+} sorption was independent of metabolic state of the organism and these by making it a suitable agent of heavy metal removal. The toxic impact of the heavy metal Cd^{2+} does not hinder the life supporting physiological process of the Cyanobacteria, hence the process of removal goes on smoothly in toxic condition.

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