

Toxicity studies and heavy metal detoxification potential biology essay

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A heavy metal is a subset of relatively- high-density elements exhibiting metallic properties, which are derived from the earth's crust, are poisonous at low concentrations and are non-degradable and non- destroyable. Heavy metals are toxic to the environment and man in many ways. Metals like mercury, cadmium, chromium, copper, arsenic, lead, nickel and manganese, to name a few have deleterious effects on the human body in that they are responsible for such disorders as attention deficit disorder, diseases of the excretory, respiratory and the nervous system, autoimmunity, cancer etc in humans and also disruptive effects in the aquatic ecosystem. Toxicity studies of heavy metals on algae can help determine the toxicity levels of these metals, as well as throw light on bioremediation potentials of algae. The current study focuses on toxicity levels and detoxification of some heavy metals using microalga *Chlamydomonas* sp. The present work involved collection of samples and sub-culturing microalgae. Stock solutions of heavy metals were added to the cultures, which after incubation were analysed by Atomic Absorption Spectroscopy. It was shown that the microalga has good potential for nickel detoxification and, to an extent, chromium detoxification.

Keywords: Heavy metal, toxicity studies, bioremediation, microalgae, *Chlamydomonas*

Introduction

Pollution in industrial areas is a serious problem of the present day (De J et al, 2008) Heavy metals are one of the major pollutants that arise in the environment due to industrial wastes. Other sources of heavy metal accumulation are mining and agriculture (Danika L, 2005). A heavy metal is a subset of relatively- high-density elements exhibiting metallic properties,

which are derived from the earth's crust, are poisonous at low concentrations and are non-degradable and non-destroyable. Thus, unless removed from a system, heavy metals will persist indefinitely (De Jaysankar, 2007). This could have harmful effects on the environment as well as living organisms including human beings. They cause diseases and disorders ranging from attention deficit disorder, respiratory disorders and damage to the nervous system to autoimmunity, cancer and even death in humans. They also have a role in disrupting the aquatic food chain. Nickel is a heavy metal that causes serious health impairments. It causes skin disease, respiratory problems, cardiovascular diseases and also spontaneous abortion in pregnant women. Structural malformations in infants born to nickel-exposed mothers are also among the harmful effects of nickel (Valeri P, 1994). It also reduces fertility, causes shrinkage of seminiferous tubules and reduction in the number of basal spermatogonia in males (ReijoKakela, 1999). Chromium, on the other hand, causes such effects as elevation of blood glucose and lactic acid levels, depletion of liver glycogen but increase in muscle glycogen content as well as an increase in the levels of enzymes like lactate dehydrogenase and succinate dehydrogenase, showing that chromium also increases the rate of glycolysis (K V Sastry, 1982). In the aquatic environment, heavy metals can have a deleterious effect on the population of algae. Since algae are among the primary producers, any adverse effect on them will be transmitted through the entire food chain dependent on algae. Thinning of the algal population due to heavy metal toxicity would cause the zooplanktons, primary consumers and secondary consumers higher up in the food chain to be deprived of food and eventually

perish, leading to disruption of the food chain and an imbalance in the aquatic ecosystem. Thus, there arises a need to rid the environment of these toxic metals or at least attempt to reduce their concentrations in the environment. Toxicity studies help gauge the levels of heavy metals that are toxic to algae. This could help industries and chemical hubs to reduce the heavy metal-content in their effluents, thus, making an endeavour to protect algae and the aquatic ecosystem. Toxicity studies could also signify the ability of microalgae to detoxify a heavy metal, a safe way of bioremediating the environment. Bioremediation refers to technology that encourages an increase in biological processes with a view to redeem many types of pollution (De J, 2007). Microalgae are a promising area of bioremediation. They have a number of ways to detoxify heavy metals. Adsorption on the cell surface is the dominant mechanism, but both surface adsorption and internal diffusion are involved in the uptake of metals by algae (Kuyucak and Volesky, 1989). The microalga used in this study, *Chlamydomonas* is a green alga, belonging to the kingdom Viridiplantae and family Chlamydomonadaceae. The genus consists of unicellular flagellates. Most species are obligate phototrophs and are found in soil, temporary pools, eutrophic lakes and also melting snow. They reproduce by both sexual and asexual means. *Chlamydomonas* is used for various studies in molecular biology, biogenesis, genetics and environmental science. It serves as a model organism for such diverse areas of study because of a simple life cycle, easy availability and easy isolation of mutants. Thus, the main aim of this study is to analyze the toxic effects of chromium and nickel in

Chlamydomonas sp. was used to assess the ability of the microalga to combat the heavy metal-induced stress with consequent detoxification.

Materials and methods:

Microorganisms and growth conditions:

Microalgae *Chlamydomonas* sp. is a unicellular green microalga. Mother culture was obtained from the Centre for Advanced Studies, University of Madras, Guindy campus, Chennai. It was sub cultured and grown in a BG11 medium containing (grams/liter) NaNO_3 - 1.5, $\text{K}_2\text{HPO}_4 \cdot 3\text{H}_2\text{O}$ - 0.004, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ - 0.075, $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ - 0.027, Citric acid ($\text{C}_6\text{H}_8\text{O}_7$) - 0.006, Ammonium ferric citrate - 0.006, EDTA - 0.001, Na_2CO_3 - 0.02 and 1 ml of microelement stock solution which contains H_3BO_3 - 2.860, $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$ - 1.810, $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ - 0.222, $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ - 0.390, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ - 0.079, $\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ - 0.0494 (grams/liter). The growth medium was adjusted to pH 6.8 and incubated at 25°C with a light source of 1000 lux. The photoperiod is in the ratio of 12: 12 of light and dark period.

Chemicals:

Stock solutions of chromium and nickel were obtained by dissolving the required quantity of potassium dichromate for chromium and nickel chloride for nickel in distilled water.

Metal toxicity test:

Metal toxicity test was done by adding the metal ion solution to the media and then studying the growth of microalgae in the particular concentration of metal with the growth of microalgae in the control. Chromium in the

concentration of 10, 20, 30, 40, 50ppm was added to the media and made up to 5 ml in test tubes, which were then inoculated with algae culture. The tests were done in duplicates and then kept in an environmental chamber at 25°C for incubation. Similarly nickel ions were added to the media in test tubes in the concentration range of 0.5ppm, 1ppm, 1.5ppm and 3 and then inoculated with microalgae (Bajguz., 2011).

Toxicity studies:

Microalgae cells were counted using a haemocytometer with a time interval of 24 hours. And the toxicity range was determined which was used for biosorption studies.

Results:

Chromium toxicity study:

The toxic effect of chromium on the microalgae cells is studied between the ranges of 10 ppm to 50 ppm. After 24 hours of exposure to chromium, it is found that the cell growth is inhibited in all the ranges of chromium. The inhibition of cell growth is less in 10 ppm of chromium comparing with other ranges of chromium. The inhibition of cell growth increased as the concentrations of chromium increased in the media and finally a high inhibition of cell growth is showed at 50 ppm of chromium. After 48 hours the cell growth is further decreased in all the ranges of chromium except 10 ppm, as the cells in 10 ppm of chromium showed a slight increase in cell growth (Figure 1). Figure1. Effect of chromium on Chlamydomonas

Nickel toxic study:

The effect of nickel on *Chlamydomonas* was studied in the range of 0.5 ppm to 3 ppm. After 24 hours of incubation, cells exposed to 0.5 ppm showed more inhibition when compared to other concentration ranges and control, whereas cells exposed to 1 and 3 ppm showed more or less similar cell count as in control. The highest cell count was found in the culture exposed to 1.5 ppm. After 48 hours of incubation, cell growth was found to be reduced when compared to the 24 hours incubated culture. The cell growth in 1.5 ppm and 3 ppm nickel, showed reduced growth when compared to the control and the growth in 1 ppm of nickel is similar to the control. After 72 hours an increase in cell growth was observed in all concentrations of nickel, a high growth is shown in 3 ppm of nickel followed by 1.5 and 1 ppm of nickel in comparing with the control. The cell growth in 0.5 ppm of nickel also increased but found to be slightly less than the control (Figure 2). Figure 2. Effect of nickel on *Chlamydomonas*

Discussion:

The chromium metal was found to be present in large amount in leather industry wastewater, Horcsik et al (2002) analyzed the toxicity of chromium on the microalgae *Chlamydomonas* his study showed that at the concentration of 20 ppm, chromium was found to be highly toxic. The result obtained in this study also showed that the chromium concentration of above 10 ppm was found to inhibit the growth of *Chlamydomonas* sp. In case of nickel toxicity on *Chlorella vulgaris*, Rehman et al. (2004) analyzed the nickel toxicity on *Chlamydomonas* at very low concentration (12 µg/l), where as in

this study nickel at the concentration of 3mg/l were analyzed for its toxicity on algae, this study concluded that there is linear increase in the growth of Chlamydomonas compared with the nickel concentration.