

## SHORT COMMUNICATION

## Long-term uptake of heavy metals by microalgae

Oghenemise Abirhire

Dept. of Plant Biology and Biotechnology, University of Benin, P.M.B.1154, Benin City, Nigeria  
droghenemise@yahoo.com; +234 8023080678

### Abstract

A study on the long-term uptake of zinc, iron, copper, cadmium and aluminum by *Chlorella vulgaris*, *Phacus curvicauda*, *Euglena acus* and *Oscillatoria bornettia* was carried out for four weeks in the laboratory. Heavy metal uptake courses can be grouped into three namely: rapid uptake during the first two weeks of the experiment (Zn and Cd by *Phacus*, *Chlorella*, *Euglena* and *Oscillatoria*; Cu by *Phacus* and *Oscillatoria*; Al by *Euglena*), continuous uptake throughout the experiment (Fe and Al by *Phacus*, *Chlorella* and *Oscillatoria*; Cu by *Euglena*) and rapid uptake during the last week of the experiment (Fe by *Euglena*).

**Keywords:** Heavy metal, *Chlorella vulgaris*, *Phacus curvicauda*, *Euglena acus*, *Oscillatoria bornettia*.

### Introduction

Metals, including heavy metals, occur in solution in almost all natural waters (Wong *et al.*, 1978). Heavy metals are among the conservative pollutants not subjected to bacterial attack or breakdown or degradation process (Igwe and Abia, 2003). The presence of heavy metals in the environment is of major concern because of their toxicity, bio-accumulating/biomagnification tendency and threat to human life and the environment (Igwe and Abia, 2003; Horsfall and Spiff, 2005). Heavy metals occur naturally in the ecosystem with large variations in concentration. Input from rivers, sediments and atmosphere are natural sources of heavy metals.

Anthropogenic sources of heavy metals include waste from electroplating and metal finishing industries, pollution from mining areas, fertilizer industries and contaminated ground waters from hazardous waste sites (Reed *et al.*, 1994). The ability of aquatic plants to take up heavy metals from water, producing an internal concentration greater than in their surroundings has been shown for many species (Whitton *et al.*, 1981). Ting *et al.* (1991) presented the mathematical model of two step uptake of heavy metals, short surface adsorption and subsequent slow uptake into the cells using Cd and Zn with *Chlorella vulgaris*. This study investigated long term uptake of 5 heavy metals by 4 species of microalgae under laboratory conditions. This will provide further information on the toxicity of heavy metals and how microalgae respond to different concentrations of heavy metals.

### Materials and methods

**Collection of algae:** The microalgae used in this study were collected from stagnant water in Benin and Warri cities in Nigeria and identified following the keys of Prescott *et al.* (1975) in the laboratory. These include *Chlorella vulgaris*, *Euglena acus*, *Oscillatoria bornettia* and *Phacus curvicauda*.

**Heavy metal solution preparation:** Heavy metal used in this study was obtained from BDH Chemicals Ltd., Poole, England. A stock solution of 100 mg/L of each heavy metal was made by dissolving: 0.16 g of CdCl<sub>2</sub> in 100 mL of distilled water, 0.44 g of ZnSO<sub>4</sub>·7H<sub>2</sub>O in 100 mL of distilled water, 0.89 g of AlCl<sub>3</sub>·6H<sub>2</sub>O in 100 mL of distilled water, 0.39 g of CuSO<sub>4</sub>·5H<sub>2</sub>O in 100 mL of distilled water and 0.72 g of Fe(NO<sub>3</sub>)<sub>3</sub>·9H<sub>2</sub>O in 100 mL of distilled water. From each heavy metal solutions, 60 µL were taken and dissolved in 1200 mL of distilled water and their concentrations was read as the initial concentrations of each heavy metal using Atomic Absorption Spectrophotometry (AAS Model- Solaar 969 Unicam Series).

**Algal inoculation:** The algae *Chlorella vulgaris*, *Euglena acus*, *Oscillatoria bornettia* and *Phacus curvicauda* used for the study were starved for two weeks before use. Twenty millimeter of the starved algae were used to inoculate the heavy metal solutions. The initial concentrations of cadmium (0.24 mg/L), zinc (0.9 mg/L), aluminium (0.49 mg/L), copper (2.72 mg/L) and iron (2.57 mg/L) solutions for a period of four weeks were noted. Each of the inoculated algae-heavy metal samples was kept outside the laboratory exposed to equal duration of sunlight and atmospheric temperature. For analysis, 20 mL of each heavy metal solutions was filtered through GFC filter paper by suction from a vacuum pump. To each of the filtrate "water" resulting from the filtration, 2 mL of nitric acid was added for digestion (Abirhire and Kadiri, 2011). Analysis of heavy metals concentrations in the water was done using Atomic Absorption Spectrophotometry (AAS Model- Solaar 969 Unicam).

### Results

Results of this study revealed three courses of long term uptake of heavy metals. Rapid uptake during the first two weeks of the experiment is shown in Fig. 1.

Fig. 1. Rapid uptake of heavy metals by microalgae during first two weeks of the experiment.

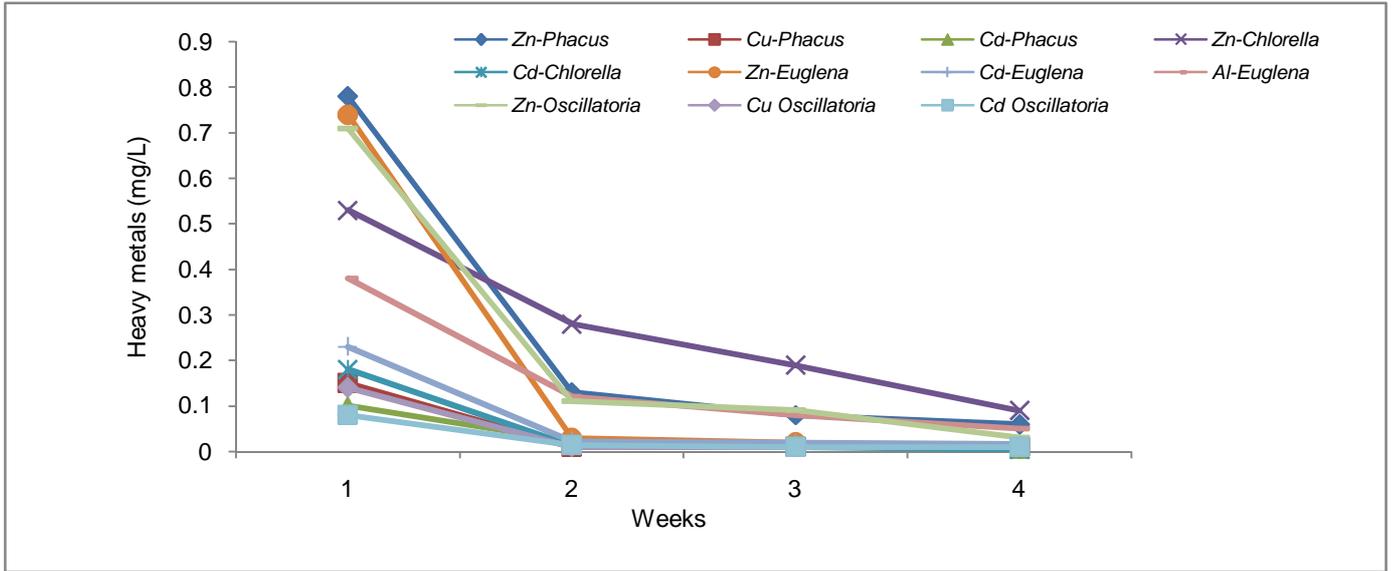


Fig. 2. Continuous uptake of heavy metals by microalgae during first two weeks of the experiment.

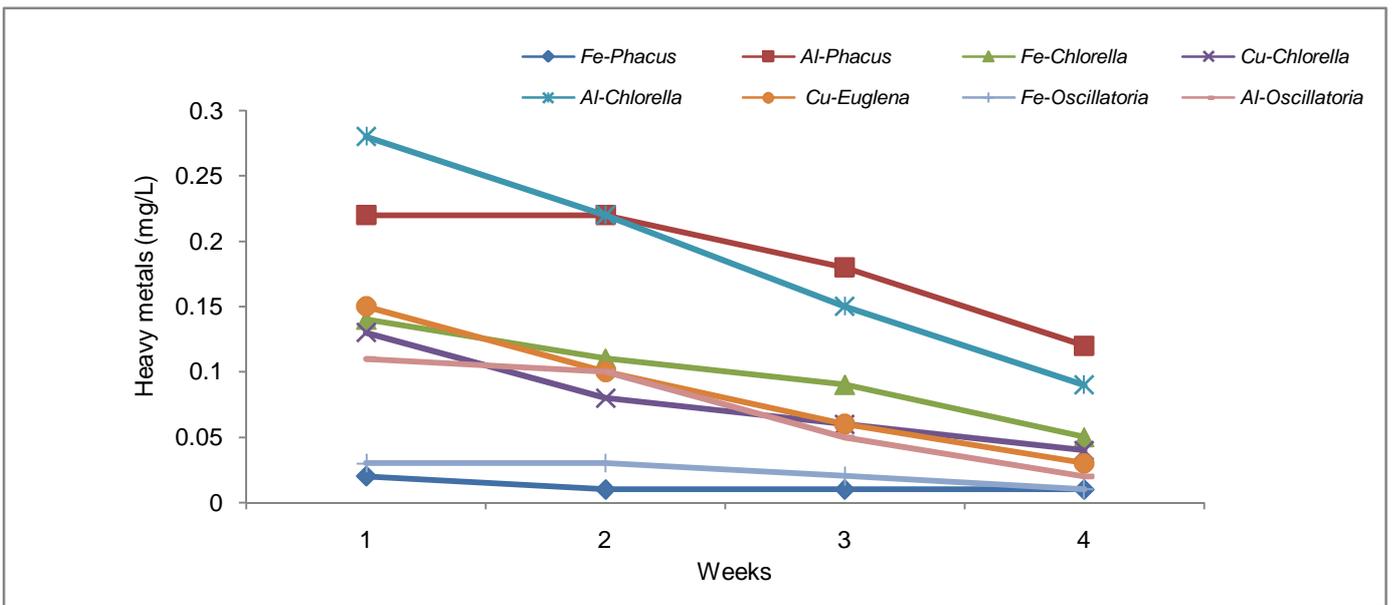
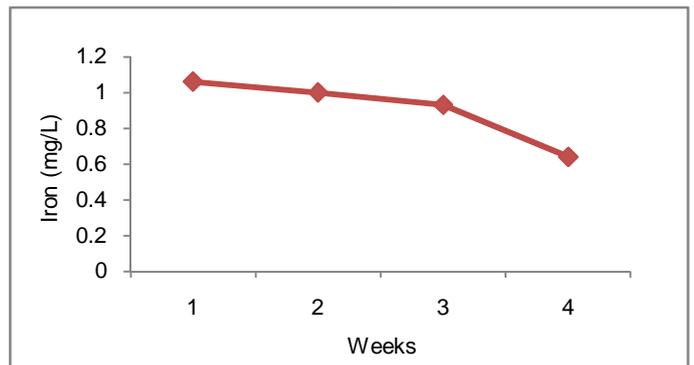


Fig. 3. Rapid uptake of Fe by *Euglena acus* during first two weeks of the experiment.



This rapid uptake during the first two weeks of the experiment pattern was observed in the uptake of Zn and Cd by *Phacus curvicauda*, *Chlorella vulgaris*, *Euglena acus* and *Oscillatoria bornettia*. The uptake of Cu by *Phacus curvicauda* and *Oscillatoria bornettia* and Al by *Euglena acus* followed the same pattern. Continuous uptake of Fe and Al by *Phacus curvicauda*, *Chlorella vulgaris* and *Oscillatoria bornettia* and Cu by *Chlorella vulgaris* and *Euglena acus* were observed throughout the experiment (Fig. 2). Rapid uptake during the last two weeks of the experiment was observed by *Euglena acus* for Fe (Fig. 3).

## Discussion

The microalgae used in this study showed long-term uptake of heavy metals for four weeks. The reason for the rapid uptake as seen during the first two weeks and last week of the experiment is the stimulation of growth of the various algae just before the metal reaches poisonous concentration (Lukavsky *et al.*, 2003). This stimulation is linked to the function of the metals in the metabolism of the algae (Maeda *et al.*, 1990), for instance, zinc and iron are co-factors for many enzyme systems. Continuous uptake according to Maeda *et al.* (1990) suggests that metals are not used in the metabolic pathway of the algae and are toxic at certain concentrations. According to Forstner and Prosi (1979) metals such as silver, mercury, cadmium and copper are more toxic even at very low levels. This corroborates with the results of the present study for iron, copper and aluminium.

## Conclusion

From this study, it was noted that microalgae employ different course in long-term uptake of heavy metals from water. This usually depends on the toxicity of the metal i.e., if the metal is used in the metabolism of the microalgae or not. Further studies on synergism, antagonism and non-reaction of microalgae with heavy metals cannot be overemphasized.

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