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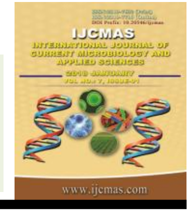

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# Bioaccumulation of Heavy Metals in Water and Algae of Mukkombu in the River Cauvery System, Tiruchirappalli District, Tamil Nadu, India

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**ABSTRACT**

Today water discharges from industries are the major causes of water pollution resulting in destabilized ecosystems. Hence, it is necessary to monitor the levels of these pollutants as well as develop technologies for the treatment of waste water. Hence, the present study was attempted to analyse the commonly occurring heavy metals in water and organisms in two stations, Musiri and Mukkombu of the River Cauvery. Results indicate that iron recorded the highest levels followed by zinc, copper, lead and cadmium with regard to metal content in organisms, *Nitzshua sigma* recorded the least metal content, while *Spirogyra quinina*recorded highest Cu content and *Oscillatorialimosa* the highest Cd content. However, *Chlorella vulgaris* recorded the highest content for Pb, Zn and Fe for both the stations.Among the two Stations, Station-II (Mukkombu) recorded the highest concentration of all the metals in both water as well as organisms. Thus, it is obvious that metals are taken up by algae.

## Introduction

The availability of water is an indispensable factor for preventing diseases and improving the quality of life (Oluduro and Adewoye, 2007). The water quality of an aquatic environment arises from its physical, chemical and biological interactions (Dec., 1989).

Aquatic ecosystem balance gets affected by human activities resulting in pollution leading to drastic deleterious effects on the system. Today waste water discharge from industries are the major causes of water pollution leading to increased oxygen demand and nutrient loading resulting in destabilized aquatic systems (Morrison *et al.*, 2001). Among the pollutants, heavy metal discharges endanger ecosystem diversity due to development of mining, smelting and other industrial activities.

Even though some metals are required as micronutrients, in organisms their increased concentration becomes toxic to most organisms (Nies, 1999; Lasat, 2002; Tangahu *et al.*, 2011; Jaiswar *et al.*, 2015). Hence, it is necessary to monitor their levels in aquatic systems as well as develop technologies for the treatment of waste water.

## Materials and Methods

The filamentous cyanoabacteria *Oscillatoria limosa* was obtained from the Mukkombu of the River Cauvery. The cyanobacteria was washed twice with tap water and then with double distilled water thoroughly to eliminate adhering foreign particles like sand and debris. The collected cyanobacterial samples were transferred to conical flasks with BG 11 medium (Rippka *et al.*, 1979). The washed biomass was first air dried for 24 hours followed by using an oven at 80° C till constant weight was recorded. The dried biomass was then ground and sieved through a sieve (2 mm) and stored in polyethylene bottles.

Batch equilibrium experiments were performed at room temperature in 250 ml Erlenmeyer glass flasks containing aqueous solution of Cd, Hg and Pb of known concentrations (20, 40, 60 and 80 $mg^{-1}$) prepared using analytical grade cadmium nitrate [Cd $(NO_3)_2$], mercuric chloride ($HgCl_2$) and lead nitrate [$Pb(NO_3)_2$]. An accurately weighed 250 mg portion of biomass was added to each flask and the mixtures were agitated on a rotary shaker at 180 rpm for different time intervals (30, 60, 90 and 120 min). Controls for each concentration without the addition of heavy metals were also maintained. After the respective agitation period, the solutions were separated from the biomass by filtration and subjected to further analysis. All the biosorption experiments were conducted in triplicates to substantiate the results. The data shown are the mean values of these replicate determinations. Heavy metal content in all the filtrates was quantified using inductively coupled plasma-optical emission spectroscopy (ICP-OES, Perkin Elmer Optima-3300 RL) at Bangalore. The amount of metal sorbed at equilibrium (mg $g^{-1}$) which represents the heavy metal uptake was calculated from the difference in metal concentration in the aqueous phase before and after absorption according to Shaik *et al.*, (2006).

## Results and Discussion

The results of the heavy metal content in the water and the organisms studied are presented in Tables 1 and 2. As evident from Table 1, the heavy metal content in waters of Station-I (Musiri) recorded levels ranging from 0.58 to 7.7 mg/l.While the lowest metal content in water was recorded by cadmium, the highest level of 7.7 mg/l was recorded by iron. In Station-II (Mukkombu), the level of heavy metals in water was found to range from 0.70 to 9.45 mg/l. However, the minimum level here also was again noticed by cadmium and the maximum level by iron.

With regard to the level of heavy metals in organisms in Station-I, copper content was found to range from 10.6 to 50.2 µg/g/dwt. The minimal copper content was found in *Nitzschia sigma* and themaximum of *Spirogyra quinae*. The other two organisms (*Oscillatorialimosa*- 11.2 µg/g/dwt and *Chlorella vulgaris*- 43 µg/g/dwt) recorded values in between. In Station-II, the copper content in organisms was found to range from 15.02 to 69.64 µg/g/dwt. Here again, the minimal level was recorded by *N. sigma* while the maximum was recorded by *S. quinina.*

Cadmium levels on the other hand was found to range from 2.4 (*N. sigma*) to 5.7 µg/g/dwt (*S. quinina*) in Station-I and from 35 (*C. vulgaris*) to 7.41 µg/g/dwt in *O. limosa*. A perusal of the lead levels reveals that in Station-I it ranged from 9.8 (*N. sigma*) to 32.6 µg/g/dwt (*C. vulgaris*) and in Station-II from 11.84 (*N. sigma*) to 38.1 mg/g/dwt (*C. vulgaris*). With regard to zinc, *N. sigma* recorded the lowest level (46.2 µg/g/dwt) and *C. vulgaris* the highest level (10.2 µg/g/dwt) in Station-I. In Station-II also, *N. sigma* recorded the lowest level (57.26 µg/g/dwt) and *C. vulgaris*, the highest level (128.1 µg/g/dwt). On the other hand, *N. sigma* recorded the lowest level of iron (134.6 µg/g/dwt), while *C. vulgaris* recorded the highest level (180 µg/g/dwt) in Station-I. In Station-II, the lowest level was recorded by *O. limosa* (164.6 µg/g/dwt) even though the maximal level was again noticed in *C. vulgaris* (191.6 µg/g/dwt).

Thus, an overall comparison of the heavy metal levels in water reveals that in Station-I, Cd recorded the lowest levels followed by lead, copper, zinc and iron while in Station-II, Cd recorded the lowest levels followed by Cu, Pb, Zn and Fe. Thus in general, the order of heavy metal in terms of content was Fe > Zn > Cu = Pb> Cd. A perusal of literature reveals that Sreenivasan (1968) recorded only traces of iron in Chengleput Pond, while in Yercaud and Ooty lake, 2 mg/l (Sreenivasan, 1964). However, Malarvizhi (1989) recorded maximum Fe levels of 37.46 mg/l in Manur Pond. Thus the present study recorded levels which are comparable to the present study. Nevertheless, Wetzel (1980) suggests that the quantity of total iron found in most typical or alkaline lakes varies from 50 to 200 mg/l.

Chatterjee (2010) on the other hand recorded copper levels in water to reach 3.95 mg/l in Damodarriver, while Jainwar *et al.,* (2015) recorded levels of 2.78 mg/l in Bhaunagar, Gujarat. A comparison of these levels with the present study reveals that the levels in the water of the present system is comparable with regard to Pb, Malarvizhi (1989) recorded Pb level in water to reach 5.8 mg/l while Ustanada (2011) recorded Pb levels to reach 5.24 mg/l, and Janwar *et al.*, (2015) recorded levels in the range of 40.47 mg/l in Sihor tributary. However, Govindasamy (2007) recorded a level of 13.0 mg/l in River Palar. Comparing these levels with the present study reveals a comparatively lower level. As far as Zn levels were concerned, Malarvzhi (1989) recorded a level of 15.16 mg/l while Govindasamy (2007) recorded a level of 40.5 mg/l and Janwar *et al.*, (2015) recorded a level of 6.24 mg/l. These levels are comparable with those obtained in the present study.

**Table.1** Heavy metals concentration in water and organisms in Station-I (Musiri, the River Cauvery)

| S. No. | Heavy metals (mg/l) | Water (mg/l) | *Chlorella vulgaris* (µg/g/dwt) | *Spirogyra quininae* (µg/g/dwt) | *Oscillatinal inosa* (µg/g/dwt) | *Nitzschia sigma* (µg/g/dwt) |
|---|---|---|---|---|---|---|
| 1. | Cu | 1.80 | 43.0 | 50.2 | 11.2 | 10.6 |
| 2. | Cd | 0.58 | 2.6 | 3.1 | 5.7 | 2.4 |
| 3. | Pb | 1.30 | 32.6 | 15.6 | 30.6 | 9.8 |
| 4. | Zn | 4.92 | 102.0 | 86.4 | 68.2 | 46.2 |
| 5. | Fe | 7.70 | 180.0 | 172.0 | 150.4 | 134.6 |

**Table.2** Heavy metals concentration in water and organisms in Station-II (Mukkombu of the river Cauvery)

| S. No. | Heavy metals (mg/l) | Water (mg/l) | *Chlorella vulgaris* (µg/g/dwt) | *Spirogyra quininae* (µg/g/dwt) | *Oscillatina linosa* (µg/g/dwt) | *Nitzschia sigma* (µg/g/dwt) |
|---|---|---|---|---|---|---|
| 1. | Cu | 2.6 | 48.6 | 69.64 | 18.83 | 15.02 |
| 2. | Cd | 0.7 | 3.5 | 5.3 | 7.41 | 4.60 |
| 3. | Pb | 2.8 | 38.1 | 19.2 | 35.82 | 11.84 |
| 4. | Zn | 6.5 | 128.1 | 104.6 | 98.4 | 57.26 |
| 5. | Fe | 9.4 | 191.6 | 180.6 | 164.6 | 170.6 |

With regard to the level of heavy metal content in organisms, *Nitzschia sigma* was found to have the least metal content for all the five heavy metals analyzed for both the stations even though exceptionally *Chlorella vulgaris* recorded minimal cadmium levels in Station-II. With regard to the maximal levels, *Spirogyra quinine* recorded highest copper levels in both stations (max. 69.64 µg/g/dwt) while highest cadmium level was noticed by *Oscillatorialimosa* in both stations (max. 7.41 mg/g/dwt). However, the maximum levels of lead (38.1 µg/g/dwt), zinc (max. 128.1 µg/g/dwt) and iron (191.6 µg/g/dwt) were uniformly recorded by *Chlorella vulgaris*. Thus, it appears that, *C. vulgaris* has the highest absorbance levels for Pb, Zn and Fe, while *O. limosa*, the highest level for Cd absorption and *S. quininae* the highest level of Cu absorption.

A perusal of literature revels that Rai *et al.*, (2008) reported Cu accumulation in *Oedogonium* at 17.78 µg/g, while Al-Homaidan *et al.*, (2011) reported *Cladophora* to accumulate 138.28 µg/g in a stream in Riyadh and Jaiswar (2015) recorded *Oedogonium* to accumulate 118.5 µg/g of Cu in fresh water system in Gujarat. However, Rajfur *et al.*, (2011) reported a copper level of 47.5 µg/g in a river in Poland, while Janwar (2015) recorded a level of 22.11 µg/g in the same species. These levels of accumulation by algae when compared to the present study are on the lower side for copper absorption.

With reference to Cd, Rajfur *et al.*, (2011) reported a level of 21.10 µg/g for *Oedogonium* and for *Cladophora*, 4.14 µg/g. On the other hand, Al-Homaidan *et al.*, (2011) recorded Cd levels of 1.08 µg/g. Rajfor *et al.*, (2011), however, noticed levels of 108.5 µg/g in *Spyrogyra*, while Janwar *et al.*, (2015) recorded levels of 9.23 µg/g in *Spirogyra*. The levels obtained by *Spyrogyra* in the present study are again in the range noted by other workers.

With regard to Pb, Eva and Jan (2001) recorded 7.9 µg/g in *Cladophora* from river Danube, while Dwivedi *et al.*, (2006) reported Pb accumulation in *Oscillatoria* to a level of 142.81 µg/g, while Janwar (2015) reported a level of 51.50 µg in *Oscillatoria*. In the present study, the results recorded for *Oscillatoria* are on the lower side when compared to others.

With regard to zinc, Javed (2006) reported zinc to accumulate in plankton to a tune of 290.13 µg/g, while Lokeshwari and Chandrappa (2007) recorded 82.0 µg/g in weed plants. Dwivedi (2006), however, recorded zinc to accumulate 277 µg/g in *Oscillatoria* while Jaiswar (2015) reported a level of 210.26 µg/g in *Oscillatoria* and

191.59 μg/g in *Oedogonium*. The present level of zinc in *Oscillatoria* recorded in this study is well below the levels noted by others.

Among the two Stations, Station-II recorded the highest concentration of all the metals in both water as well as organisms. Thus, it is obvious that metals are taken up by algae. Dwivedi (2012) suggested that the metal ions are absorbed over the cell surface very quickly and then transported slowly into the cytoplasm.

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