# Bioremediation of Pb(II) and Ni(II) by live *Dunaliella salina* microalgae: A green dynamic approach

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*Abstract*— The potential of *Dunaliella salina* for bioremediation of Pb(II) and Ni(II) ions in aqueous solution has been examined under optimized culture conditions. For the selective Pb(II) biosorption in the presence of Ni(II), single and binary systems of ions were chosen. *Dunaliella salina* algae showed maximum Pb(II) and Ni(II) biosorption with 96% and 55% efficiency respectively. Involvement of the surface morphology of the microalgae biomass and elemental distribution was studied through Scanning Electron Microscope (SEM) and Fourier-transform infrared spectroscopy (FTIR) analysis.

## 1. INTRODUCTION

The environmental contamination of heavy metal ions due to industrial discharges such as mining, tannery, petroleum refining, metallurgical and manufacturing activities have become environmental disposal problems. [1, 2]. Pb(II) and Ni(II) as heavy metal ions are used in a wide range of commercial procedures. In comparison to conventional techniques, biological adsorption suitable for heavy metal ions removal from wastewater.

*Dunaliella salina (D. salina)* is one type of green microalgae with a very high capacity for binding metal ions due to the presence of functional groups which can cross-link with heavy metal ions [2]. Moreover, the growth curve of live microalgae shows the complexity of the production of biosorbents in different stages of the growth kinetics. Most models for biosorption using biomass rely on simple mathematics of a constant amount of biosorbent being added to the solution at the beginning of the process. When using live microalgae, due to the constant production of biosorbent at different rates, most of the classical models fail to explain the process [3]. The aim of the current research is to investigate the efficiency of live *D. salina* algae as an economical biosorbent for wastewater treatment in a dynamic process.

## 2. METHODOLOGY

Pb $(NO_3)_2$ (Merck) and Ni $(NO_3)_2\cdot 6H_2O$ (Sigma-Aldrich) were used in stock solutions. The concentration of Pb(II) and Ni(II) in the solution was determined using an atomic absorption spectrophotometer (AAS). The surface morphological features and functional groups of the *D. salina* were analyzed using SEM and FT-IR spectrometry. To study the influence of heavy metal ions on total biosorption Pb(II) and Ni(II) with a concentration range of 0-300.0 mg $L^{-1}$ were examined.

## 3. REZULTS AND DISCUTION

In order to investigate the effect of competitive ions on heavy metal ion biosorption efficiency, simultaneous Ni(II) and Pb(II) biosorption from binary heavy metal ion solutions were examined (Table. 1).

Table1. Comparison of single and binary biosorption

| Concentration (mg $L^{-1}$) | | Biosorption% | | |
|---|---|---|---|---|
| Pb(II) | Ni(II) | Pb(II) | Ni(II) | Total |
| 50 | 0 | 96.19±2.1 | 0 | 96.19 |
| 50 | 50 | 98.73±4.7 | 35.63±0.6 | 67.18 |
| 50 | 100 | 97.51±7.2 | 28.64±0.9 | 63.07 |
| 50 | 150 | 97.10±7.8 | 20.18±0.5 | 58.64 |
| 50 | 200 | 96.86±5.5 | 18.42±0.6 | 57.64 |
| 50 | 250 | 95.97±3.7 | 12.15±0.4 | 54.06 |
| 50 | 300 | 95.51±4.6 | 10.80±1.2 | 53.15 |
| 0 | 50 | 0 | 55.88±1.2 | 55.88 |
| 50 | 50 | 98.73±4.7 | 35.63±0.6 | 67.18 |
| 100 | 50 | 95.32±2.3 | 28.43±0.8 | 61.87 |
| 150 | 50 | 91.92±1.1 | 19.91±1.5 | 55.91 |
| 200 | 50 | 87.34±2.1 | 17.11±1.3 | 52.22 |
| 250 | 50 | 85.44±1.8 | 12.10±0.5 | 48.77 |
| 300 | 50 | 80.51±2.7 | 10.60±0.6 | 45.55 |

It was observed that the percentage of Pb(II) biosorption decreased from 96.19 to 95.51 But, the amount of Ni(II) biosorption decreased from 35.63% to 10.80%. This phenomenon shows a competitive effect among Ni(II) and Pb(II) ions. In next section, similar pattern was observed by Ni(II) in the presence of Pb(II) as cometettive ions. It may be due to the possible interaction between various types of metal ions and *D. salina* cell wall as a dynamic sorbent in biosorption systems.

FT- IR spectra before and after heavy metal ions biosorption were recorded to identify the functional groups on the *D. salina* surface. The FT-IR spectra are shown in Fig. 1 for the *D. salina* surface.

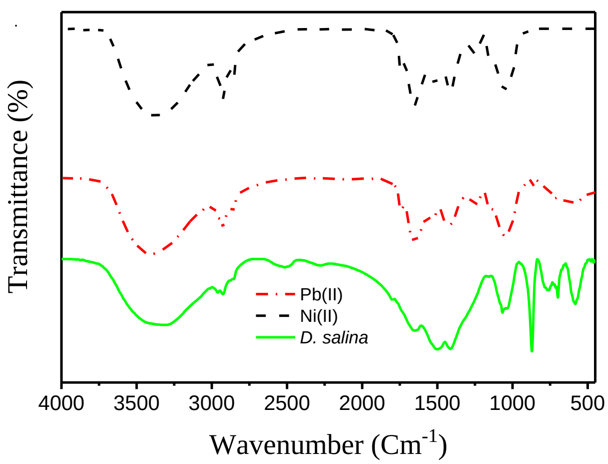


**Fig. 1.** FT-IR spectra of the *D. salina* after and before Pb(II) and Ni(II) biosorption

The SEM image in (Fig. 2a) indicates a rough and irregular surface with porous texture of *D. salina* as a control sample that provides the interaction with heavy metal ions in aqua solution. In contrast, (Fig. 2b & c) show that *D. salina* surface with considerable differences after biosorption of Pb(II) and Ni(II) respectively.

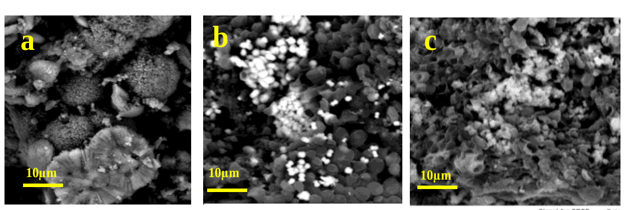


**Fig. 2.** SEM images before heavy metal ions biosorption by D. salina (a) and after uptake Pb(II) (b), and Ni(II) (c)

## 4. Conclusion

Biosorption of Ni(II) and Pb(II) have been investigated for single and binary systems. The biosorption capacity is highest for Pb(II) as compared to Ni(II) for all systems. The morphology and structure properties of *D. salina* were characterized by SEM and FT-IR. In the present study, *D. salina* was directly grown in saline water and used to treat heavy metal ions from contaminated waters. This is a feasible solution to environmental problems. Research findings, led to the recommendation of a novel model for using live microalgae as an eco-friendly and green approach that avoids the usage of any chemicals that may impose serious damage to the environment.

## ACKNOWLEDGMENT

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