# Removal of heavy metal Ions from Aqueous Solution by Adsorption on a Low-Cost Biomass

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# Contents

# Introduction

- Deterioration of water resources due to heavy metal pollutants, such as lead and cadmium and other metals, have become an emerging concern for environmental agencies and governmental authorities around the world.
- The accumulation and persistence of such heavy metals in the food chain elevate its threat of toxicity, even when found at low concentrations in water .
- The increment of heavy metals pollution comes from industrial revolution and transportation activities that contribute heavily with heavy metal discharge to the environment.
- Nowadays, ecosystem pollution with heavy metals is becoming a crucial environmental problem threatening the marine life in the western coastline of Saudi Arabia.
- Ions of heavy metals are toxic and bio-accumulative, with further biomagnification. Therefore, purification of water from heavy metals is an important issue for human beings

# Introduction

Different methodologies have been applied to minimize heavy metals pollution in water resources treatment to reduce the health risks associated with heavy metal contamination., such as

- precipitation
- coagulation
- nanomaterials
- ion exchange
- oxidation/reduction
- adsorption
- and biosorption methods

**Abdulaziz N. Amro ,Mohammad K. Abhary ,Muhammad Mansoor Shaikh and Samah Ali *Processes,* 2019, *7*(7), 406**
**Abdulaziz Amro, Mohammad K . Abhary, Polish journal of environmental science, Vol. 28, No. 5 (2019), 1-8.**
**Abdulaziz N. Amro ,Mohammad K. Abhary, International journal of Phytoremediation (2019)21(14)1457-1462**

- Phragmites australis was recently reported as an invasive species in the area stretching from north to south of the Red Sea shoreline in Saudi Arabia.
- it is considered a useful model for understanding

when and how species become invasive, because of its ability to establish, survive, expand and modify the environment within which it persists.

- Live biomass cultures of Phragmites australis has been used in numerous studies for heavy metals water treatment because of its ability to accumulate such ions within its tissues

Phragmites australis

## *Zygophyllum coccineum*

a xero halophyte species growing on the coastline of the Yanbu industrial area Certain xero halophytic species growing on the coastlines of the Red Sea have been explored for their adaptation to heavy metal pollution They have been found to be hyper accumulators for Cu, Fe,Pb, Zn, and other heavy metals, and to be salt tolerant.

## *Cladophora sp.*

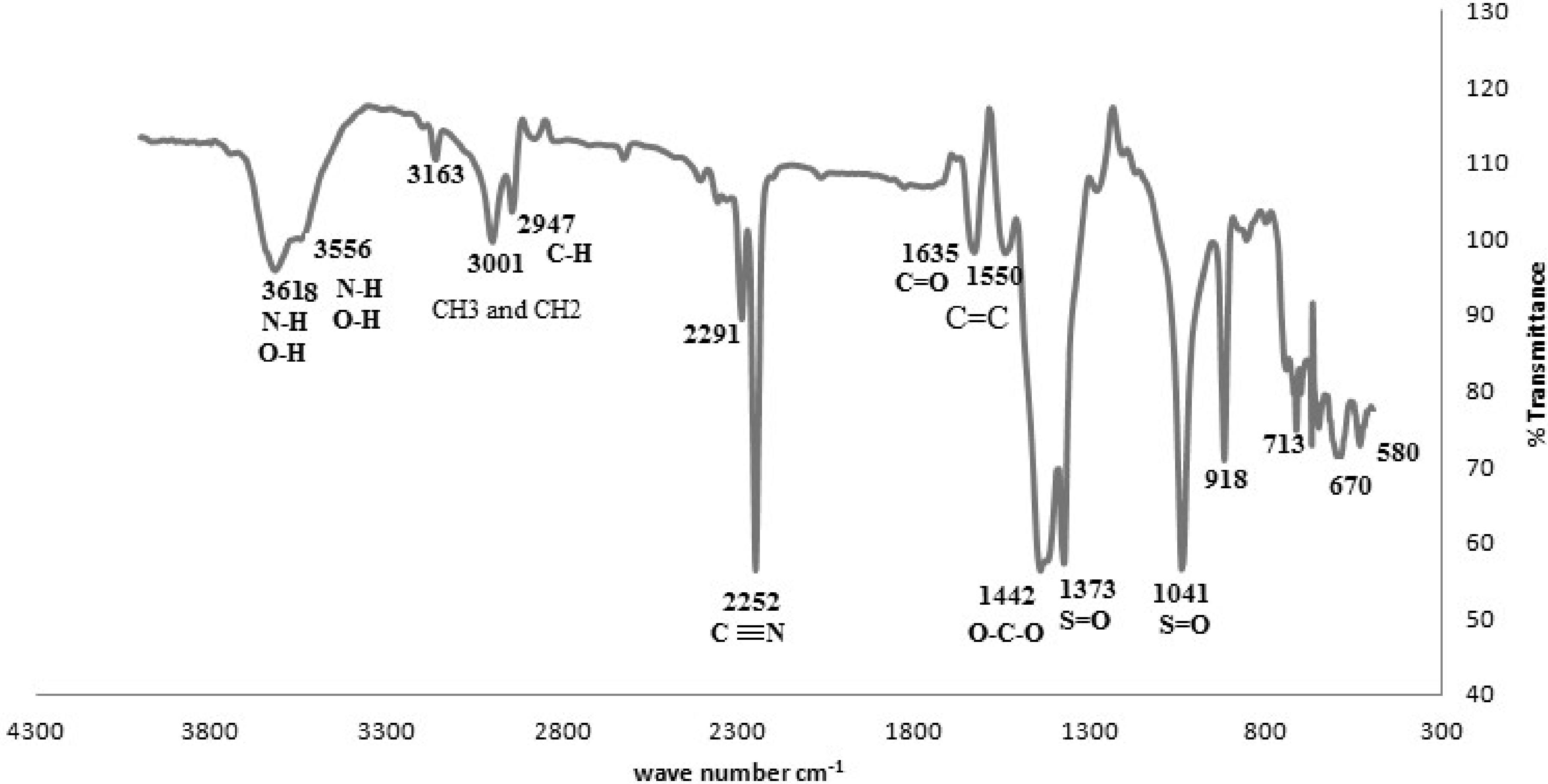
The genus Cladophora is a member of the Ulvophyceae alga class, recorded in shallow waters of Jeddah and Obhor regions on the western shores of Saudi Arabia.

It is used in the area as indicators for heavy metal pollution in wastewater due to their ability to adsorb heavy metals from the surrounding environment.

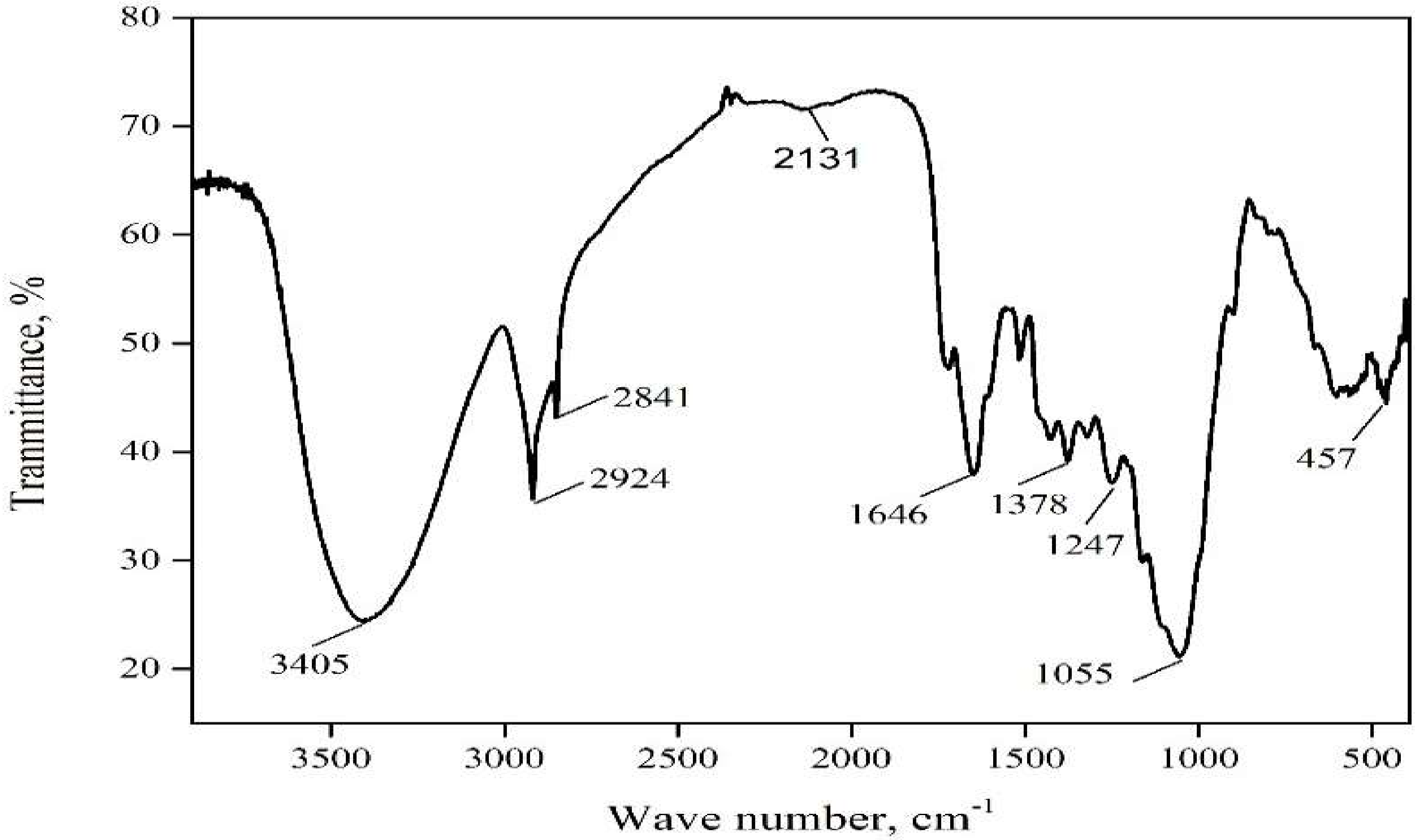
# Biomass preparation

- Samples of Cladophora sp. green algae , Phragmites and Zygophyllum coccineum were collected from different locations of Yanbu beach
- Samples were immediately soaked and washed with tap water and then rewashed three times with distilled water.
- The biomass was dried overnight in a 45°C oven and ground using a commercial blender.
- Powdered biomass was sieved through different mesh sizes <0.125, 0.125-0.212, 0.212-0.5, 0.5-1.0 and 1.0-2.0 mm.

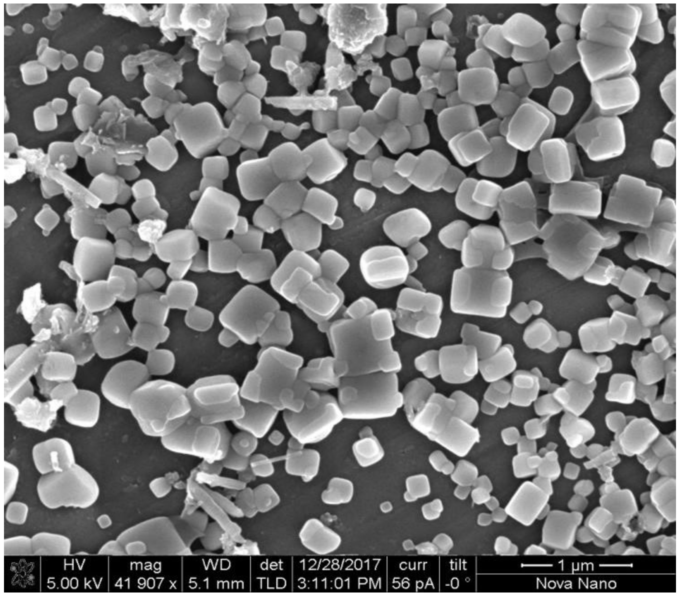
# FTIR spectra of Cladophora biomass



# FTIR spectra of treated phragmites biomass

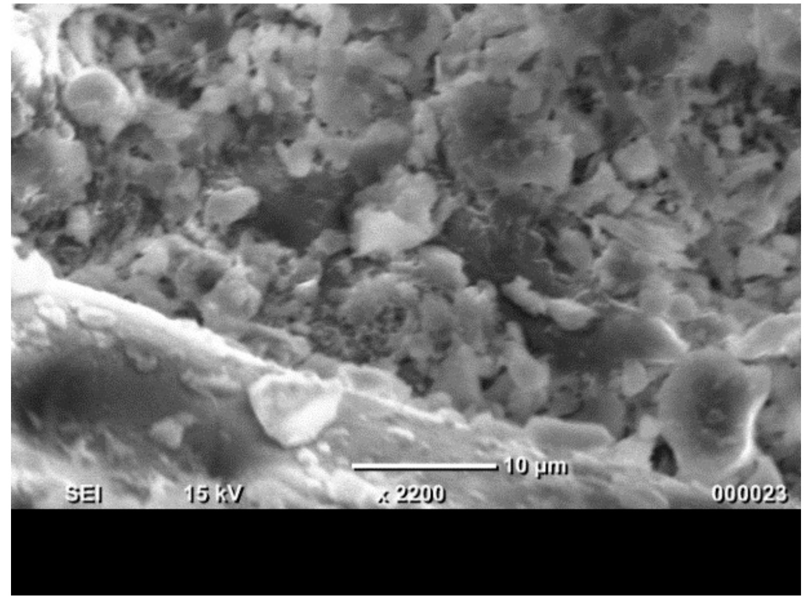


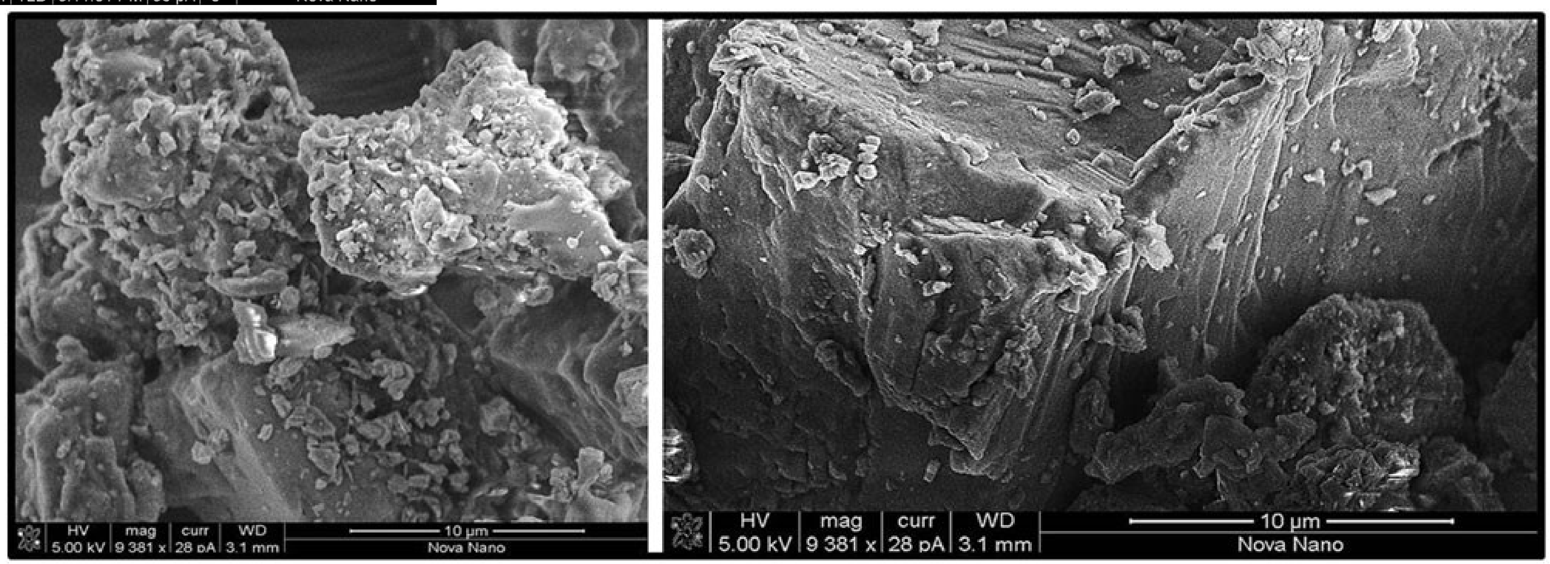
# Scanning electron microscope




*Cladophora*

Phragmites



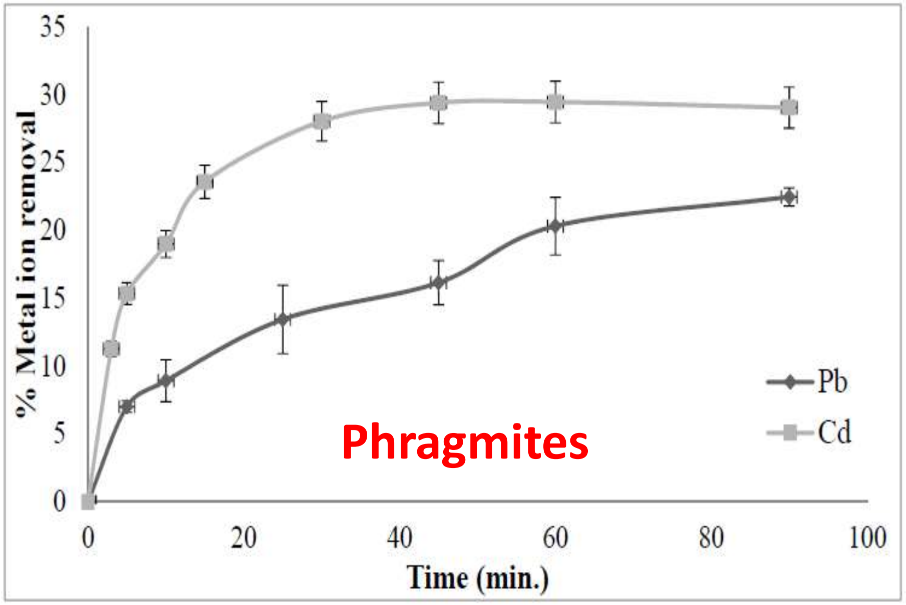

Z. coccineum

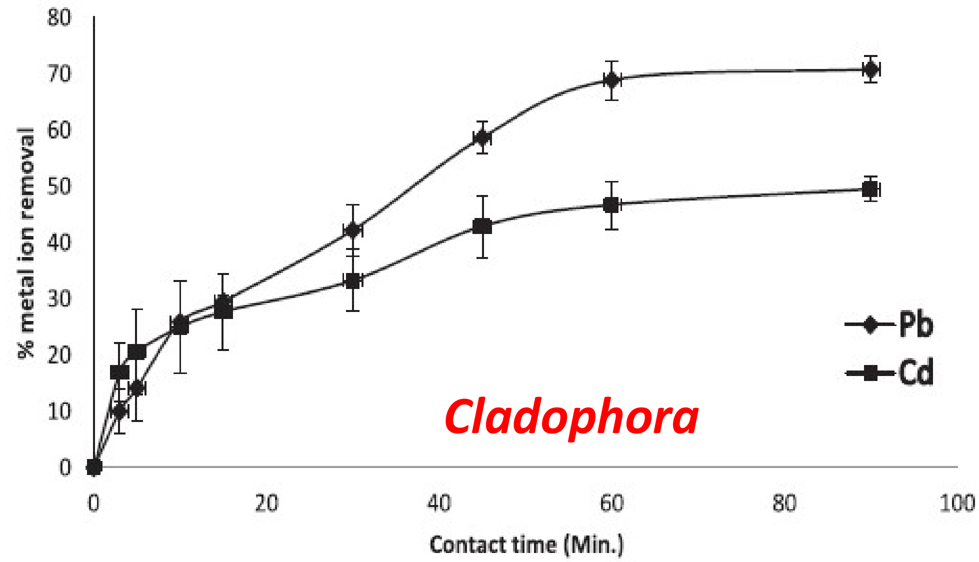
# Surface area

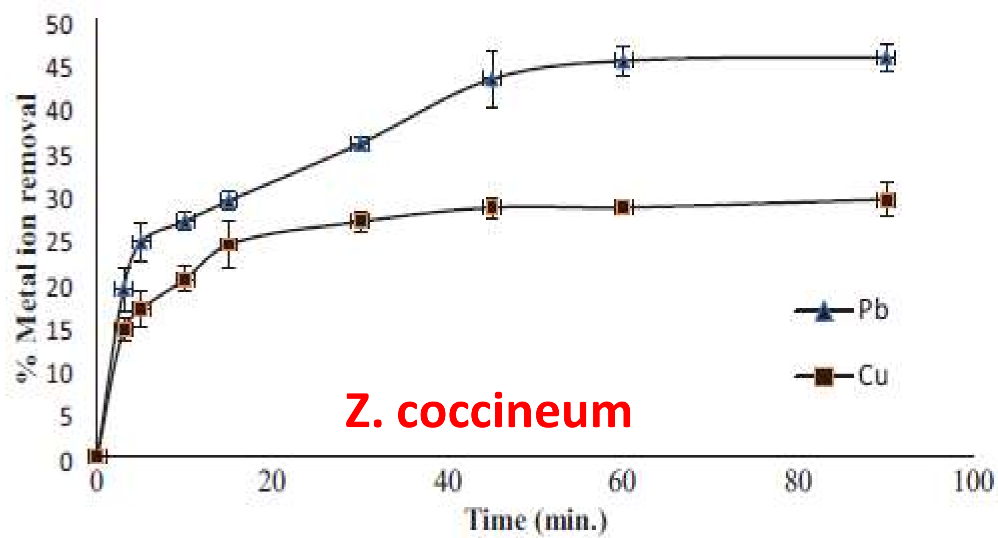
| Biomass | Surface area |
|---|---|
| Cladophora | 1.7062 $m^2/g$ |
| Phragmites | 0.5331 $m^2/g$ |
| Z. coccineum | 0.6863 $m^2/g$ |

# Heavy metal ions removal parameters

**Effect of contact time on metal ion removal (mean±RSD) (50 mL, 50 ppm) using *biomass (0.2 g, 0.212-0.5 mm)* (120 RPM, pH 5, 25ºC)**

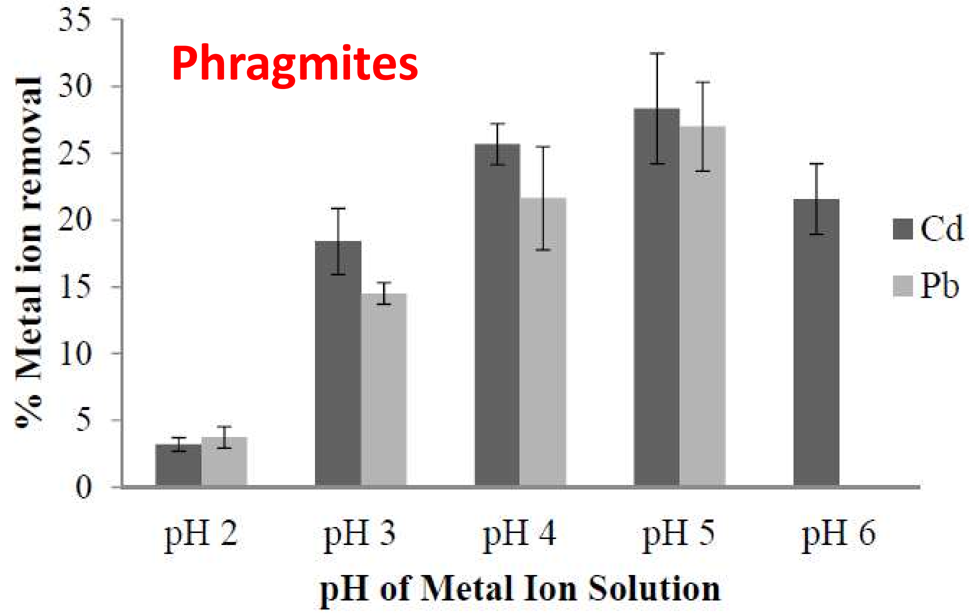


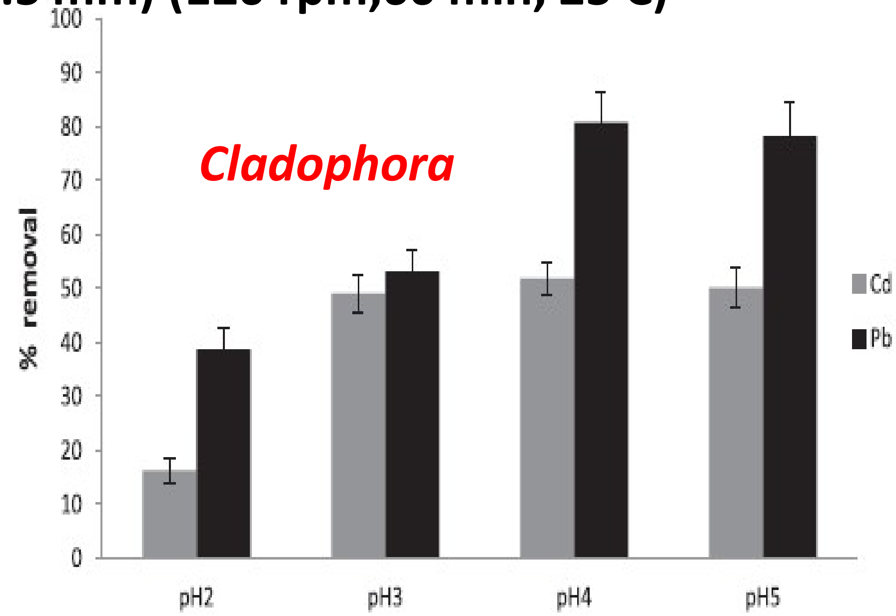



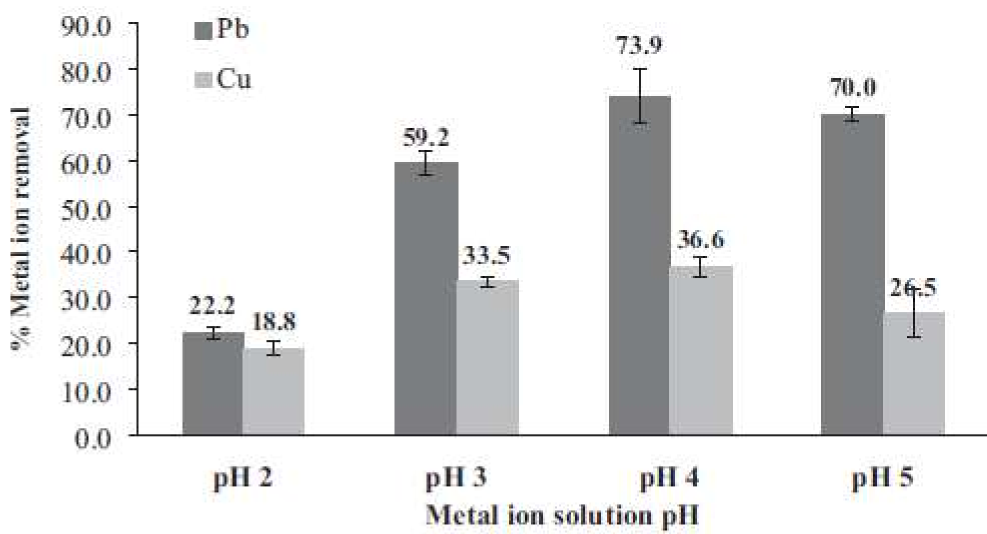



# Effect of pH

**Effect of solution pH on metal ion removal (mean ± RSD) (50 mL,50 ppm) using powdered biomass (0.2 g, 0.212–0.5 mm) (120 rpm,60 min, 25 C)**

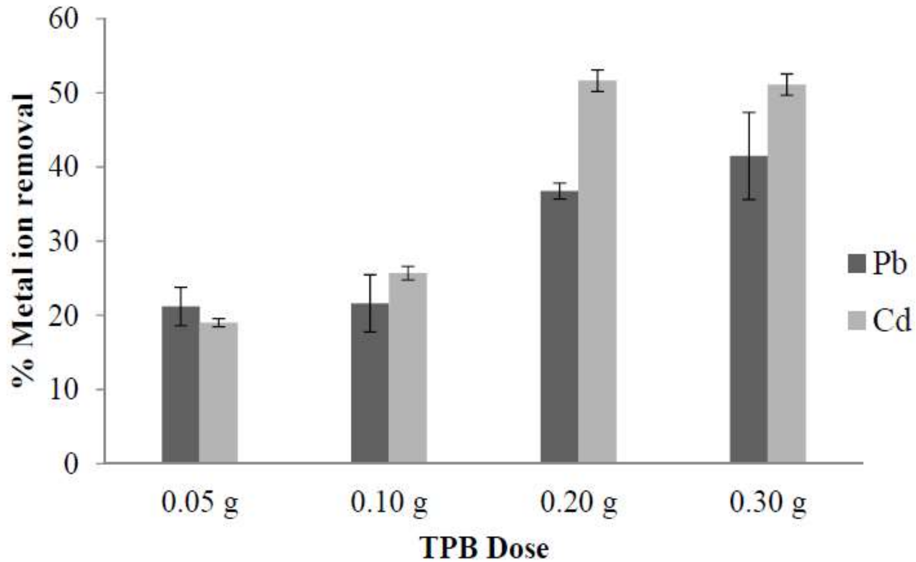


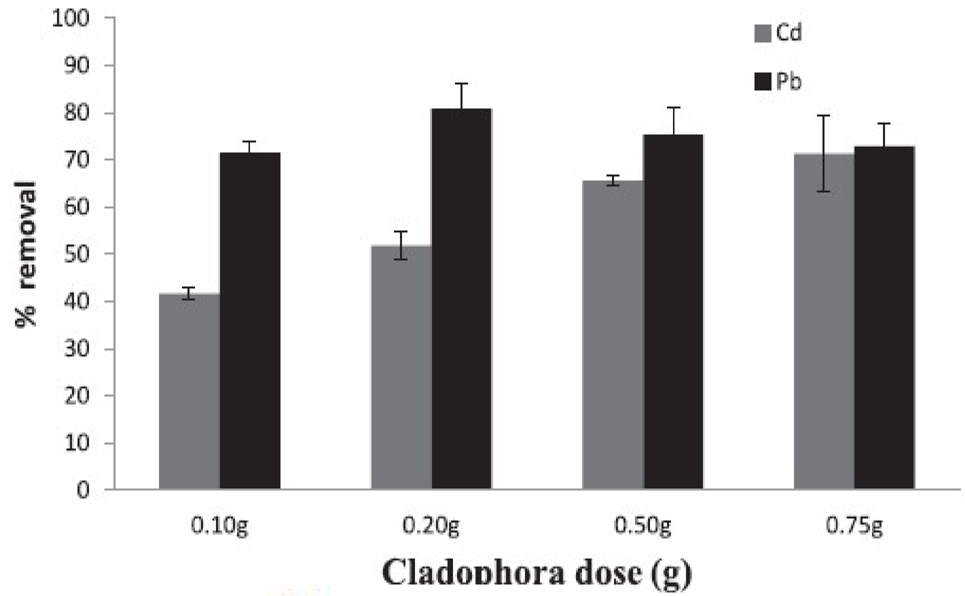



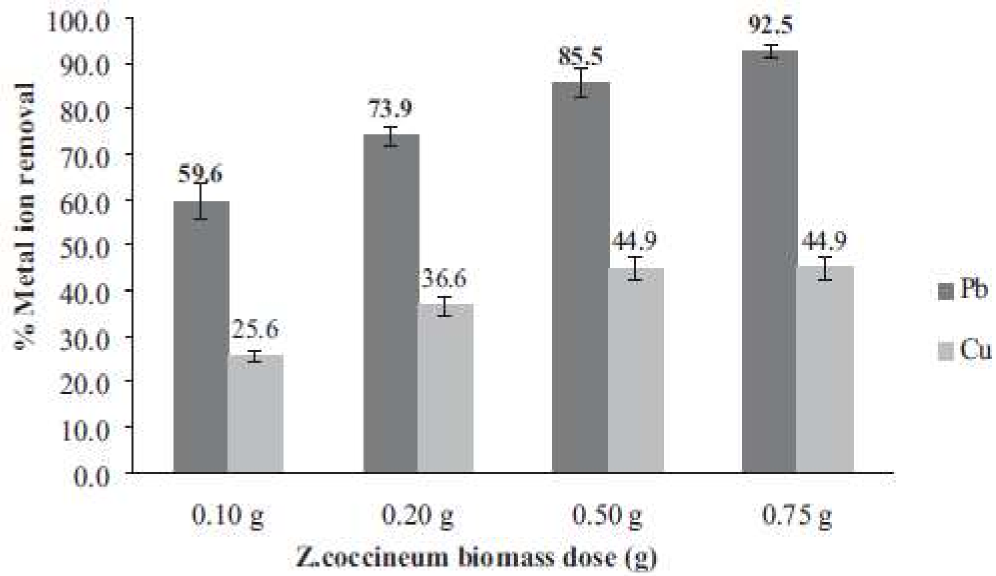




Z. coccineum

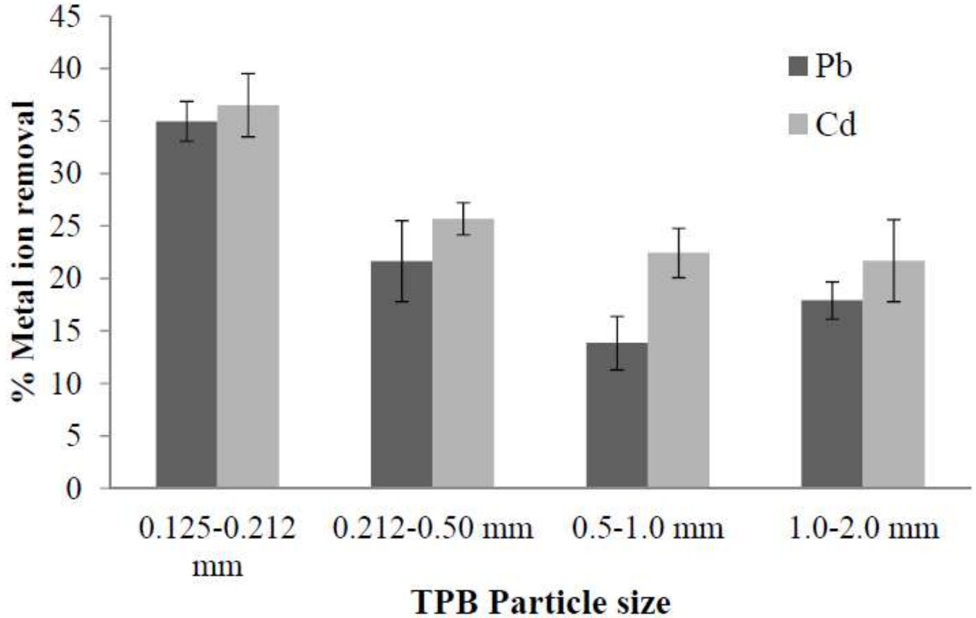
## Effect of biomass dose (0.212–0.50 mm) on metal ion removal (mean ± RSD) (50 mL, 50 ppm, pH 4) (120 rpm, 60 min, 25 C)

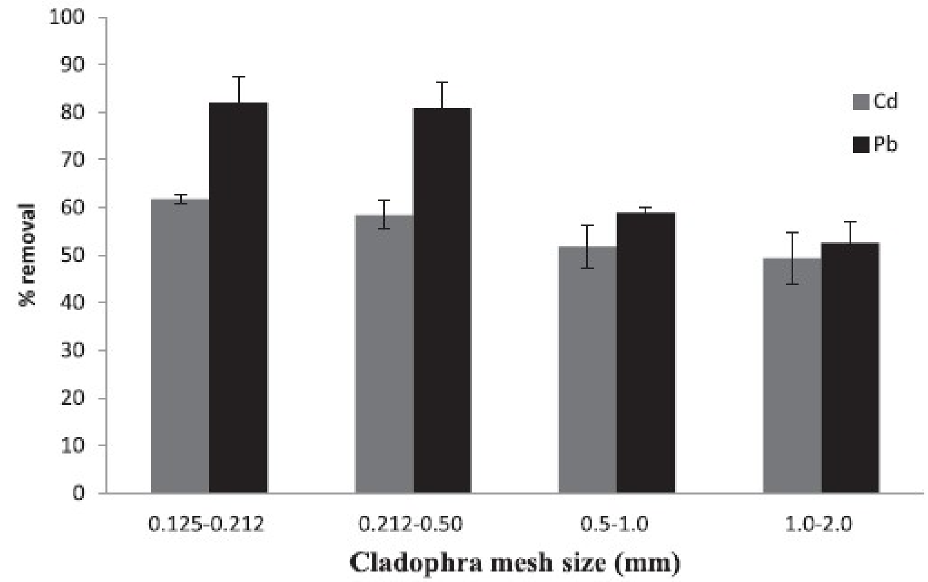


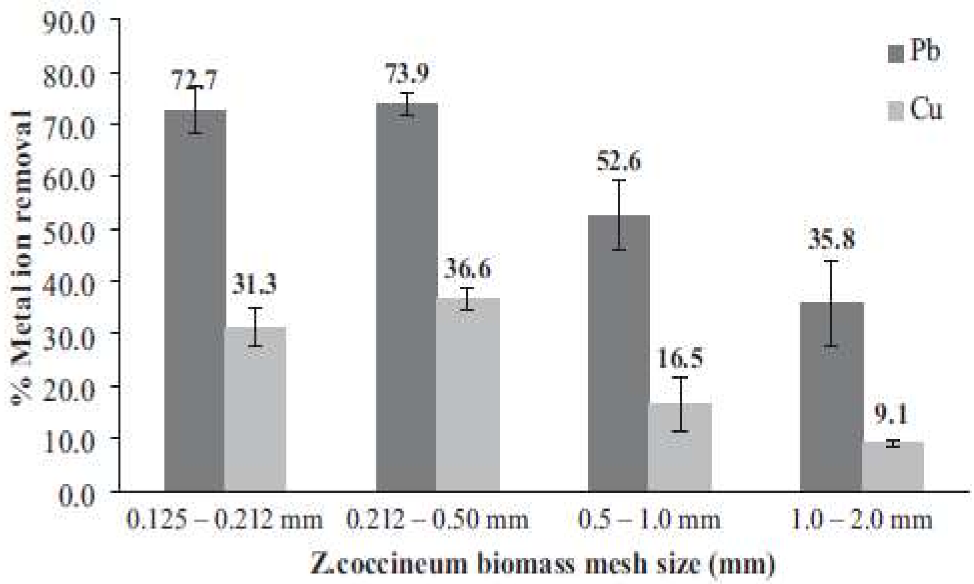



## Effect of particle size on metal ion removal (mean ± RSD)(50 mL, 50 ppm, pH 4) (120 rpm, 60 min, 25 C)

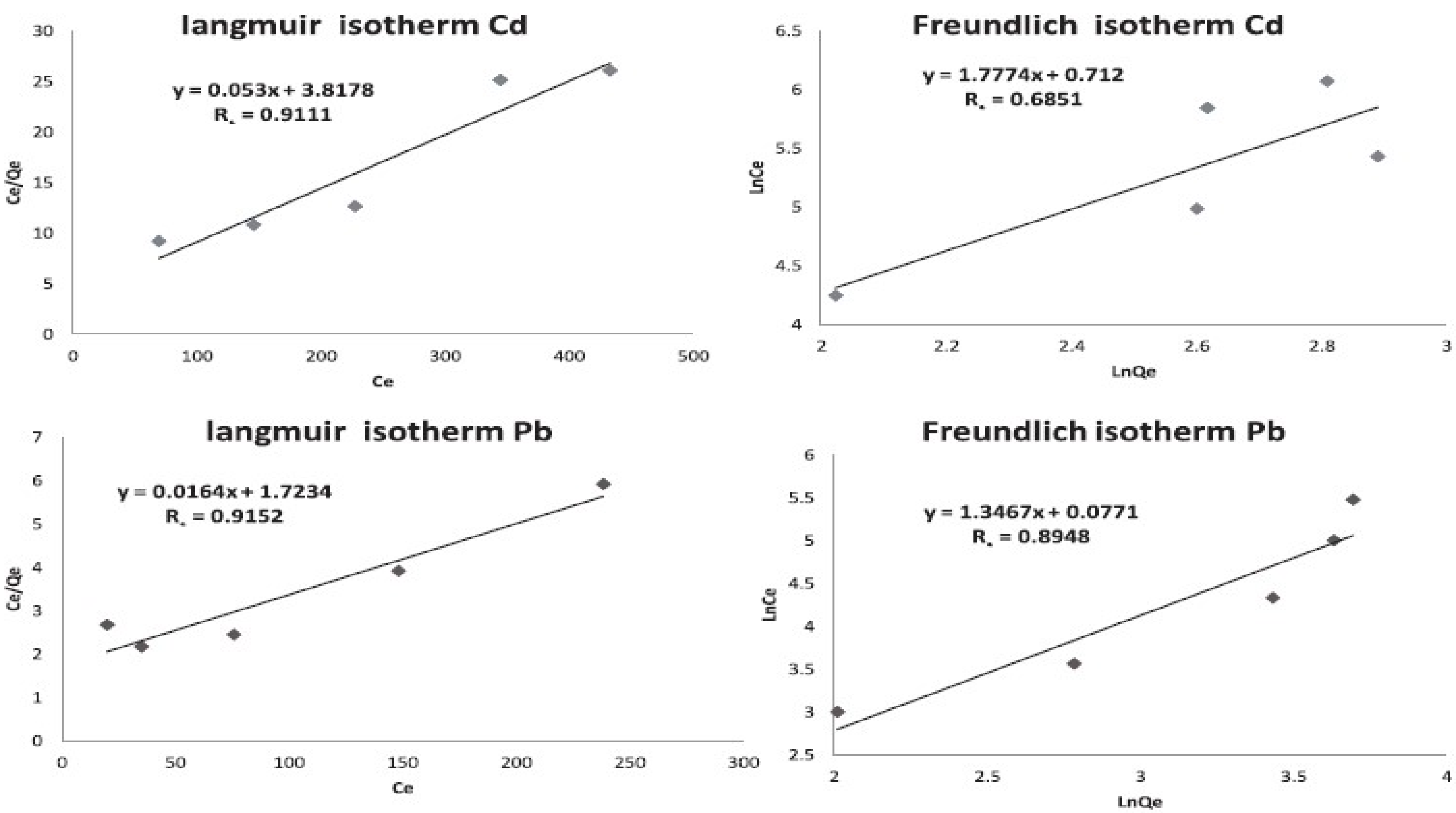


# isothermal and kinetic studies

- Langmuir and Freundlich isotherms




***Cladophora* biomass**

# Z. coccineum

| Metal ion | Langmuir isotherm model | | |
|---|---|---|---|
| | *Xm* | *K* | $R^2$ |
| Pb (II) | 25.51 | 0.0158 | 0.9751 |
| Cu (II) | 14.79 | 0.0041 | 0.6903 |
| | Freundlich isotherm model | | |
| | *Kf* | 1/*n* | $R^2$ |
| Pb (II) | 2.5919 | 0.3714 | 0.7772 |
| Cu (II) | 0.2837 | 0.5861 | 0.8612 |

# Phragmites

| | Langmuir Isotherm | | | Freundlich Isotherm | | |
|---|---|---|---|---|---|---|
| | $X_m$ (mg/g) | K (L/mg) | $R^2$ | KF | 1/n | $R^2$ |
| Pb | 5.46 | 0.1625 | 0.936 | 1.689 | 0.287 | 0.743 |
| Cd | 6.40 | 0.0395 | 0.918 | 0.805 | 0.418 | 0.724 |

# Sorption Kinetics

| Metal ion | Pseudo First order kinetic model | | | |
|---|---|---|---|---|
| | $Q_{e,\,exp}$ (mg $g^{-1}$) | $Q_{e,\,calc}$ (mg $g^{-1}$) | $k_1$ ($h^{-1}$) | $R^2$ |
| Pb | 20.56 | 24.60 | 0.9375 | 0.9417 |
| Cd | 12.07 | 9.20 | 1.419 | 0.9858 |
| | Pseudo Second order kinetic model | | | |
| | $Q_{e,\,exp}$ (mg $g^{-1}$) | $Q_{e,\,calc}$ (mg $g^{-1}$) | $k_2$ (g $mg^{-1}h^{-1}$) | $R^2$ |
| Pb | 20.56 | 28.4 | 0.0348 | 0.9919 |
| Cd | 12.07 | 13.33 | 0.0741 | 0.9936 |

***Cladophora biomass***

## Z. coccineum

| Metal ion | Pseudo first-order kinetic model | | | |
|---|---|---|---|---|
| | $Q_{eexp}$ (mg g$^{-1}$) | $Q_{ecalc}$ (mg g$^{-1}$) | $k_1$ (h$^{-1}$) | $R^2$ |
| Pb | 5.71 | 4.923 | 4.059 | 0.9350 |
| Cu | 3.67 | 1.805 | 3.197 | 0.9468 |
| | Pseudo second-order kinetic model | | | |
| | $Q_{eexp}$ (mg g$^{-1}$) | $Q_{ecalc}$ (mg g$^{-1}$) | $k_2$ (g mg$^{-1}$h$^{-1}$) | $R^2$ |
| Pb | 5.71 | 6.184 | 1.301 | 0.9937 |
| Cu | 3.67 | 3.836 | 3.797 | 0.9997 |

## Phragmites

| Metal Ion | Pseudo First Order Kinetic Model | | | |
|---|---|---|---|---|
| | $Q_{e, exp}$ (mg g$^{-1}$) | $Q_{e, calc}$ (mg g$^{-1}$) | $k_1$ (h$^{-1}$) | $R^2$ |
| Pb | 0.335 | 0.101 | 1.048 | 0.9505 |
| Cd | 0.765 | 0.153 | 1.104 | 0.7404 |
| **Metal Ion** | **Pseudo Second Order Kinetic Model** | | | |
| | $Q_{e, exp}$ (mg g$^{-1}$) | $Q_{e, calc}$ (mg g$^{-1}$) | $k_2$ (g mg$^{-1}$ h$^{-1}$) | $R^2$ |
| Pb | 0.335 | 0.393 | 7.452 | 0.9718 |
| Cd | 0.765 | 0.821 | 14.96 | 0.9966 |

# conclusions

- Certain kinds of algae and seaweeds have been collected from salt marshes and treated to be used as alternative biomass adsorbent to remove metal ions from aqueous solution.
- Even though studied biomasses have low surface areas, they are considered a good adsorbents of metal ions from aqueous solution, when considering the abundance of low-cost raw materials used for its preparation.
- Thermodynamic and kinetic investigations indicated that adsorption of metal Langmuir homogenous monolayer chemisorptionions on biomass fit
- Further studies are recommended for the removal of other metal ions and organic pollutants.

# Thank you