# Application of Marine Algae on the Uptake of Gold (III) in Aqueous Solutions

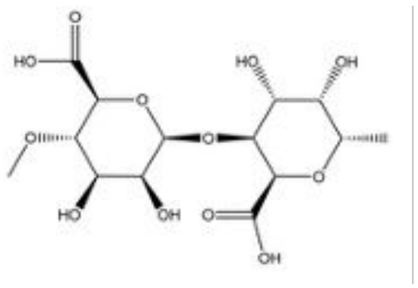
**Sarina Vélez, Fatma Zehra Gulluce, Abel E. Navarro PhD**

Science Department, Borough of Manhattan Community College, CUNY, New York, NY

## Introduction

Increasing demands continue to fuel the gold market industry and the search for new mines, less expensive extractions, and purifying techniques are of top priority. Today, toxic extractions for the retrieval of Gold (III), which involve cyanide are still being used, causing severe consequences for ecosystems and human health. This issue highlights the need to develop newer and safer techniques for the recovery and capture of gold in aqueous systems.

**Figure 1:** Disaccharide of polyalginic acid



In this project, the use of marine algae Lessonia nigrescens Bory (L13) and Macrocystis integrifolia Bory (S12) were closely examined for the uptake of gold (III) ions in aqueous solutions.

## Aim

MOFs (metal-organic frameworks) and modified clays are not renewable adsorbent materials and they involve an extra cost that is not sustainable in developing countries for the extraction of Gold. Our aim is to evaluate the potential of both Marine brown algaes as an abundant, eco-friendly material and inexpensive adsorbent for the uptake of Gold (Au3+) ions.

**Image 1:** Lessonia nigrescens Bory

**Image 2:** Macrocystis intergrifolia Bory

## Materials and Methodology

**Gold (III) solution:**

- Stock solutions of 1000 mg/mL were prepared by dissolving gold (III) chloride (AuCl3) of analytical grade in 1L of deionized water. Solutions of varying concentrations were prepared through dilution of the stock solution until the desired concentration was reached.

**Preparation of adsorbents:**

- Brown marine algae Lessonia nigrescens Bory (L13) and Macrocystis integrifolia Bory (S12) were obtained from the beaches of Tacna and Marcona in Peru.
- Both marine algae had been washed twice with tap water to remove soil, other microscopic algae, insect larvae, etc. They were washed, and taxonomically identified. To eliminate the presence of any metallic ions on the adsorbents, both algae were shaken at 250 rpm during 3 h in a 3M HCl solution.
- Both algae samples were washed with type I water until neutral washes were obtained with a litmus paper. Adsorbents were then dried at room temperature, ground, sieved to a particle size of 75 µm-106 µm and stored in plastic containers until their use.

**Adsorption Experiments:**

- Batch experiments were carried out in triplicate at room temperature combining variable masses of L13 and S12 with 50 mL of a solution of Au (III) of varying concentrations with orbital agitation at 200 rpm during 12 h.
- Adsorption time was determined in preliminary assays.
- Effects of initial solution pH, adsorbent dose, initial Au (III) ions concentration and salinity were studied one at the time by changing only one experimental parameter. Blank samples, without adsorbent, were simultaneously studied to determine the initial metal ion concentration under the same experimental condition

**Analysis of Data:**
The adsorption efficiency was expressed as Adsorption Capacity (q, mg/g) and Adsorption Percentage (%ADS) using the following equations:

$$q = \frac{(C_i - C_{eq})x\,V}{m}$$

M is the mass of adsorbent in g, V is the volume of the solution in L and Ci and Ce are the initial and at the equilibrium concentrations of auric ions, respectively in mg/L.

## Results

**Table 1:** Constants and Parameters of the Adsorption Isotherms of Au (III) ions on L13 and S12 algae

| Adsorption Isotherm | *Lessonia nigrescens Bory* (L13) | *Macrocystis integrifolia Bory* (S12) |
|---|---|---|
| **Langmuir** | | |
| $q_{max}$ (mg/g) | 224.22 | 59.312 |
| b (L/g) | 0.049 | 0.272 |
| $R^2$ | 0.953 | 0.996 |
| *p*-value | <0.001 | <0.0001 |
| **Freundlich** | | |
| $K_F$ (L/g) | 35.899 | 21.361 |
| 1/n | 0.373 | 0.276 |
| $R^2$ | 0.9913 | 0.977 |
| *p*-value | <0.001 | 0.0015 |
| **Dubinin-Radushkevich** | | |
| $q_{max}$ (mg/g) | 135.047 | 54.88 |
| B x $10^{-12}$ ($mol^2/J^2$) | 1.429 | 0.804 |
| E (kJ/mol) | 591.335 | 788.515 |
| $R^2$ | 0.9958 | 0.973 |
| *p*-value | <0.0001 | 0.0019 |

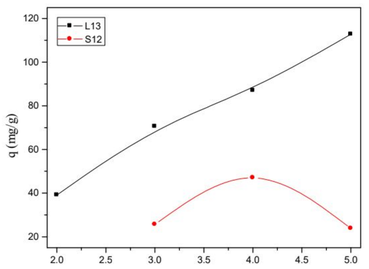
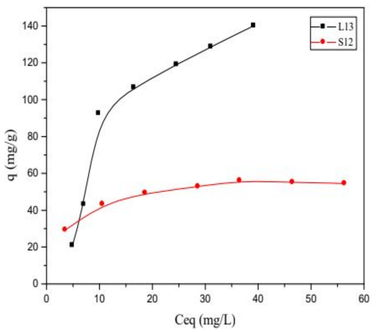



**Figure 2:** Effect of the initial pH on the adsorption of Au (III) ions onto L13 and S12.

**Figure 3:** Adsorption Isotherms of Au (III) ions on the brown algae L13 and S12




## Results cont.

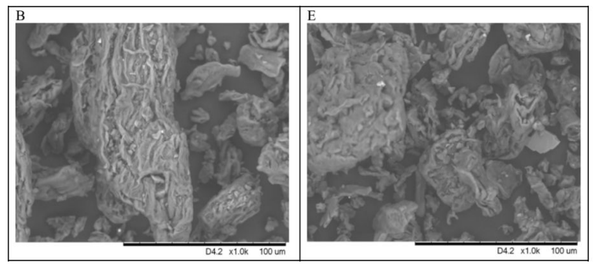



**Figure 4:** The morphological and textural properties of both marine algae were studied with scanning electron microscopy (SEM), using a TableTop microscope (TM3000, Hitachi). L13 and S12 were observed under different zooms to explore the heterogeneity of their surfaces.

## Conclusion

- Brown marine algae are composed of alginates and fucoidans in their structure, whose functional groups high absorption properties towards metal ions (sulfonic, carboxyl and hydroxyl).
- Adsorption isotherms models were fitted to the data, reporting maximum Langmuir adsorption capacities of 224 and 59 mg of Au (III) per gram of L13 and S12, respectively. Pseudo-second order kinetics model adjusted to the time-dependence data, suggesting that the mechanism is controlled by the adsorption step
- Gold (III) adsorption was maximized at an initial solution pH between 4 and 5 and slightly favored in the presence of sodium nitrate.
- Scanning electron microscopy indicates that L13 and S12 pose favorable morphological and textural properties for the uptake of metal ions, whereas thermogravimetric analysis demonstrates optimum thermal and mechanical resistance of both algae.
- This study shows the potential of inexpensive marine algae as eco-friendly materials for the removal of precious metals from aqueous solutions.

## References

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