



# KINETICS, THERMODYNAMIC AND ISOTHERMS MODELING OF THE EQUILIBRIUM SORPTION OF $\text{Pb}^{2+}$ , $\text{Ni}^{2+}$ AND $\text{Cd}^{2+}$ INTO TIGER NUT CHAFF (*CYPERUS ESCULENTUS*) FROM MODEL WASTEWATER

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## INTRODUCTION

Heavy metals have harmful effects on human health, and exposure to these metals has been on the increase and contamination of water by toxic metals is an environmental concern and hundreds of millions of people are being affected around the world.[1].

The discharge of these pollutants into the environment, especially water bodies has been on the rising due to urbanization and industrialization such as pharmaceutical, textile, paints production, metal finishing, mining, battery manufacturing and electroplating respectively. Large number of waste produce from these industries contains heavy metals which is the cause of environmental pollution [2].

**AIM:** The purpose of this study was to establish the mechanism of removal of heavy metals from model wastewater using tiger nut chaff as a sustainable alternative agricultural waste adsorbent in wastewater treatment applications.



## MATERIALS AND METHODS

**COLLECTION AND PREPARATION OF ADSORBENT:** The Tigernuts (TN) were obtained from First Gate market, along Lasu-Iba road, Iba local Government of Lagos State. The powdered form of TN was stored and used for the study.

**MATERIALS, REAGENT AND INSTRUMENTS:** Tigernut chaff, measuring cylinder, beaker, conical flask standard flask, sample bottles, funnels, filter paper, sieves, blender, analytical balance, distilled water, oven shaker, Scanning Electron Microscope, FTIR Spectrophotometer, Atomic Absorption Spectrophotometer.



**PREPARATION OF STOCK SOLUTION:** A stock solution of 1000mg/L of soluble salt of  $\text{Pb}^{2+}$   $\text{Ni}^{2+}$  and  $\text{Cd}^{2+}$  was prepared dissolving their respective water-soluble salts of  $\text{PbCl}_2$ ,  $\text{Ni}(\text{NO}_3)_2$  and  $\text{CdCl}_2$  in denoised water respectively; then the working solution is prepared from the stock. The pH of each of the working solution was adjusted to desired value by drop-wise addition of 0.1M HCL and NaOH.



## RESULTS

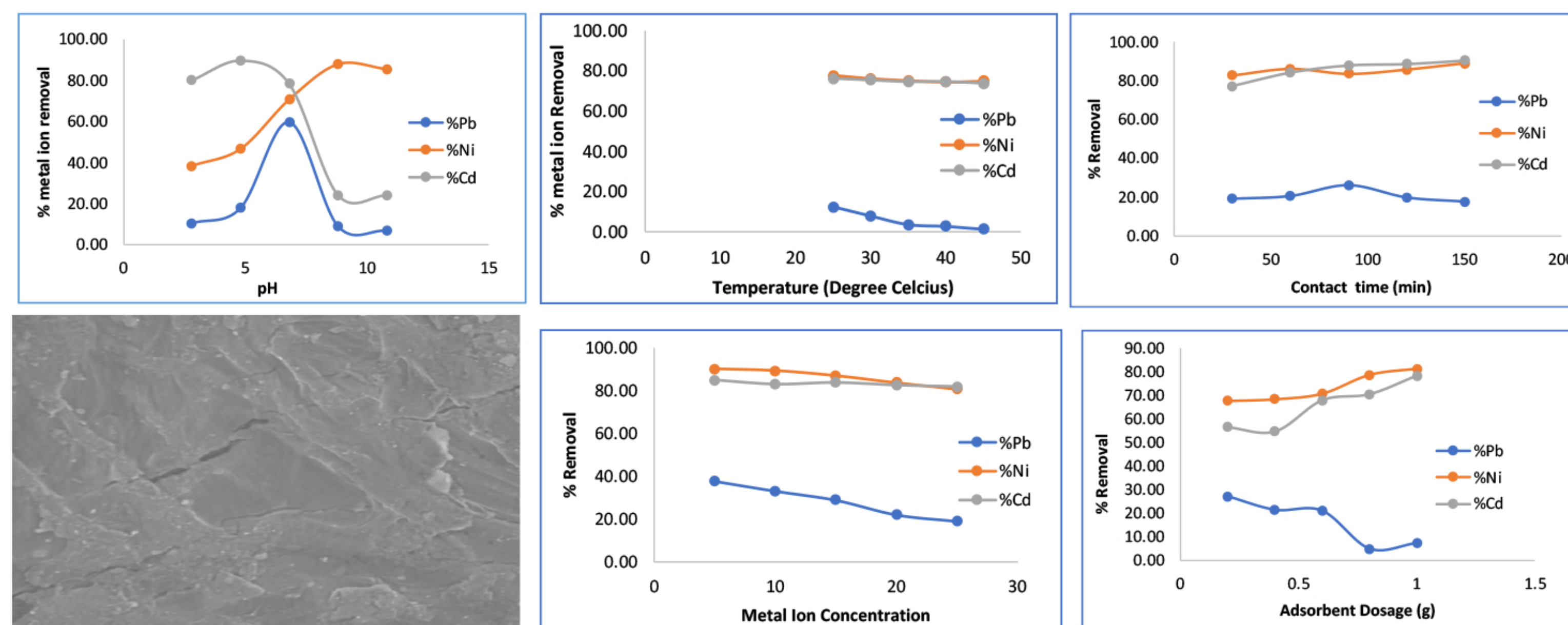


Figure 1: SEM Before Adsorption

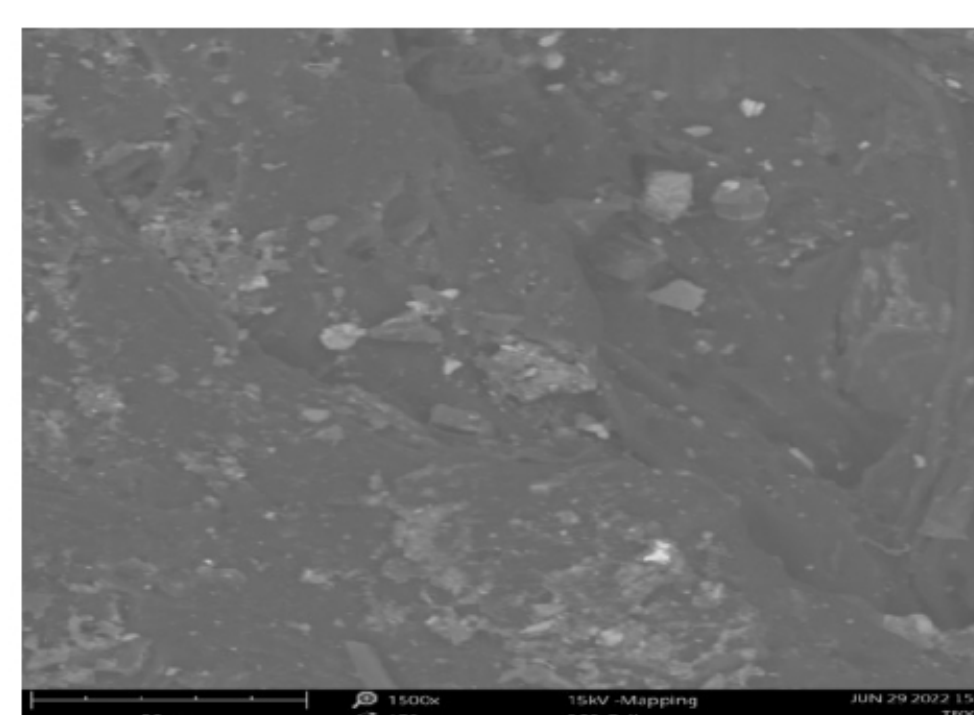


Figure 2: SEM After Adsorption

**Table 2:** Adsorption isotherm parameter for the adsorption of  $\text{Pb}^{2+}$ ,  $\text{Ni}^{2+}$  and  $\text{Cd}^{2+}$  ions using *Cyperus esculentus*

| Isotherm Model      | Metal Ion        | $Q_m(\text{mg/g})$       | $b (\text{L/mg})$ | $R^2$  |
|---------------------|------------------|--------------------------|-------------------|--------|
| Langmuir Isotherm   | $\text{Pb}^{2+}$ | -0.008                   | 5.16              | 0.9879 |
|                     | $\text{Ni}^{2+}$ | -1.0179                  | 0.16              | 0.9999 |
|                     | $\text{Cd}^{2+}$ | -0.906                   | 0.21              | 0.9999 |
|                     | Metal Ion        | n                        | $K_f$             | $R^2$  |
| Freundlich Isotherm | $\text{Pb}^{2+}$ | -0.28                    | 149.42            | 0.9954 |
|                     | $\text{Ni}^{2+}$ | -3.19                    | 5.2               | 0.9995 |
|                     | $\text{Cd}^{2+}$ | -3.01                    | 4.23              | 0.9995 |
|                     | Metal Ion        | A ( $\text{L mg}^{-1}$ ) | B                 | $R^2$  |
| Temkin Isotherm     | $\text{Pb}^{2+}$ | 1.495                    | 2.4683            | 0.8589 |
|                     | $\text{Ni}^{2+}$ | -1.5065                  | 3.8327            | 0.9682 |
|                     | $\text{Cd}^{2+}$ | -0.685                   | 0.6752            | 0.7646 |

**Table 1:** Kinetic Model Parameter of  $\text{Pb}^{2+}$ ,  $\text{Ni}^{2+}$  and  $\text{Cd}^{2+}$  ions using *Cyperus Esculentus*

| Kinetic Model       | Metal ion        | $q_e$   | $K_1$   | $R^2$  |
|---------------------|------------------|---------|---------|--------|
| Pseudo First Order  | $\text{Pb}^{2+}$ | 0.6693  | 0.0138  | 0.0900 |
|                     | $\text{Ni}^{2+}$ | 1.0205  | 0.0375  | 0.9963 |
|                     | $\text{Cd}^{2+}$ | 11.2047 | 0.0412  | 0.9586 |
|                     | Metal ion        | $q_e$   | $K_2$   | $R^2$  |
| Pseudo Second Order | $\text{Pb}^{2+}$ | 0.1526  | -0.6296 | 0.9452 |
|                     | $\text{Ni}^{2+}$ | 0.2544  | 1.1585  | 0.9979 |
|                     | $\text{Cd}^{2+}$ | 0.3146  | 0.4570  | 0.9999 |

**Table 3:** Thermodynamic parameters for the adsorption of  $\text{Pb}^{2+}$ ,  $\text{Ni}^{2+}$  and  $\text{Cd}^{2+}$  ions using *Cyperus Esculentus*

| Metal Ion        | Temp (K) | $\Delta H (\text{KJ/mol})$ | $\Delta S (\text{KJ/mol/K})$ | $\Delta G (\text{KJ/mol})$ |
|------------------|----------|----------------------------|------------------------------|----------------------------|
| $\text{Pb}^{2+}$ | 298      | -0.0648                    | 0.5969                       | -177.95                    |
|                  | 303      |                            |                              | -180.93                    |
|                  | 308      |                            |                              | -183.91                    |
|                  | 313      |                            |                              | -186.89                    |
| $\text{Ni}^{2+}$ | 318      |                            |                              | -189.88                    |
|                  | 298      | -0.8414                    | 1.2288                       | -367.02                    |
|                  | 303      |                            |                              | -373.17                    |
|                  | 308      |                            |                              | -379.31                    |
|                  | 313      |                            |                              | -385.46                    |
| $\text{Cd}^{2+}$ | 318      |                            |                              | -391.6                     |
|                  | 298      | -0.8414                    | -0.8414                      | -479.53                    |
|                  | 303      |                            |                              | -487.56                    |
|                  | 308      |                            |                              | -495.59                    |
|                  | 313      |                            |                              | -503.61                    |
|                  | 318      |                            |                              | -511.64                    |



## DISCUSSION & CONCLUSION

Taking into account its good adsorption capacity, ease of sample treatment, as well as availability, the biomass of tigernut (TN) is a promising cost-effective bio sorbent for  $\text{Pb}^{2+}$ ,  $\text{Ni}^{2+}$  and  $\text{Cd}^{2+}$  removal from aqueous environment.

Morphological characterization using Scan electron microscope (SEM) confirms adsorption of heavy metal in the tiger nut chaff. The FT-IR analysis showed that possible functional groups responsible for adsorption are C=O, NH, CO, OH and other smaller groups that cannot be identified using only FT-IR spectra.

The Thermodynamic studies showed that the adsorption process was feasible, exothermic and proceeded spontaneously, demonstrating that Tiger-Nut (TN) chaff can be used as a sustainable alternative for the effective removal of  $\text{Pb}^{2+}$ ,  $\text{Ni}^{2+}$  and  $\text{Cd}^{2+}$  from model wastewater. This study is in accordance with Sustainable Development Goal 3 (Good Health and well-being) and Goal 6 (Clean Water and Sanitation)



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