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# *Study of Thermodynamic Parameters in Adsorption of Lead, Copper and Cadmium Metal Ions by Plant Sorbents*

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## *ABSTRACT*

This research was carried out in laboratory scale using dried leaves powder of Thuja and Populus as sorbents to remove lead, copper and cadmium ions from aqueous solution. The effect of temperature on metal ions removal by sorbents was evaluated, the equilibrium data was fitted by Langmuir, Freundlich and Dubinin-radushkevich isotherms and thermodynamic constants were determined. For this purpose, solutions with different concentration of ionic metals were prepared. Sorbent amount equal to 10 gr/lit , pH = 5 and detention time 60 minutes for all sorbents were adjusted. Studied temperatures were 20, 25, 35, 45 ºC. The results have shown that increasing the initial concentration, increases the adsorption capacity. The Langmuir model was found to best describe the data, although some adsorption processes were described with more than one model. This research indicated that the adsorption of metal ions by Populus was endothermic and adsorption of them by Thuja was exothermic processes. Determination of the thermodynamic parameters, Gibbs free energy ($\Delta G^{o}$) and the mean adsorption free energy (Ea) showed that the adsorption of metal ions by two plants was physical.

***KEYWORDS:***

Plant Sorbent, Metal Ions, Thermodynamic Constants, Isotherm

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## 1- Introduction

Toxic heavy metals contamination of industrial wastewater is an important environmental problem. The commonly used procedures for removing metal ions may be ineffective or expensive, especially in high concentration. Biosorption, is a process that utilized inexpensive biomass to sequester toxic heavy metals from water and wastewaters. In a study, the potential to remove Zn (II), Cd(II) and Mn(II) from aqueous solutions through biosorption using maize stalks as an agriculture waste, was investigated in batch experiments. Different factors influencing metal adsorption such as contact time, initial metal ion concentration, pH, ionic strength and temperature were investigated. The adsorption process was relatively fast and equilibrium was established after about 90 min. The optimum initial pH for zinc, cadmium and manganese adsorption by maize stalks was 7.0, 6.0 and 5.0, respectively. Under optimum conditions, the maximum adsorption capacity of zinc, cadmium and manganese ions was 30.30, 18.05 and 16.61 mg metal/g dry biomass, respectively. Various equilibrium models were analyzed and deduced the Langmuir adsorption model fitted successfully at the studied temperature and concentration range. The adsorption process was found to be spontaneous and exothermic [1].

## 2- Methodology, Discussion, Results

In this study, the dried leaves powder of Thuja and Populus were used as sorbents to remove lead, copper and cadmium ions from aqueous solution. Metal solutions were prepared from nitrate salts of lead, copper and cadmium in the laboratory. The effect of temperature on metal ions removal by sorbents was evaluated, the equilibrium data was fitted by Langmuir, Freundlich and Dubinin-radushkevich isotherms and thermodynamic constants were determined. Sorbent amount equal to 10 gr/lit, pH = 5 and detention time 60 minutes for all sorbents were adjusted. Studied temperatures were 20, 25, 35, 45 ºC. The results have shown that increasing the initial concentration, increases the adsorption capacity until it reaches a maximum adsorption capacity (saturation) and then remains constant.

The parameters values of Langmuir, Freundlich and Dubinin-radushkevich isotherms for the absorption of lead, copper and cadmium by Thuja and Poplar adsorbents are shown in the table 1.

According to the results, the theoretical $q_{max}$ obtained from the Langmuir equation is in best agreement with the experimental of it. In this research, Langmuir isotherms separation factor (RL) is between zero and one for each of the adsorbents that represents the desired system [2]. Less than one the numeric values of 1/n in the Freundlich equation indicates the favorable adsorption of three metals [3].

**Table 1. Metal ions adsorption parameters by Thuja and Populus sorbents**

| Sorbent | Metal | T °K | Langmuir | | | | Freundlich | | | Dubinin-radushkevich | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $r^2$ | $q_{max}$ | b | $R_L$ | $r^2$ | $K_f$ | 1/n | $r^2$ | β | $q_m$ | $E_a$ |
| Thuja | Pb | 293 | 0.980 | 143 | 0.0026 | 0.1333 | 0.966 | 1.00 | 0.670 | 0.892 | 1 | 85 | 0.46 |
| | | 318 | 0.990 | 143 | 0.0012 | 0.2500 | 0.985 | 3.09 | 0.794 | 0.890 | 312 | 36 | 0.04 |
| | Cu | 293 | 0.992 | 125 | 0.0018 | 0.1613 | 0.970 | 2.93 | 0.746 | 0.932 | 25 | 60 | 0.14 |
| | | 318 | 0.986 | 42 | 0.0011 | 0.1852 | 0.960 | 12.1 | 0.778 | 0.955 | 81 | 24 | 0.08 |
| | Cd | 293 | 0.983 | 111 | 0.0024 | 0.0769 | 0.990 | 1.80 | 0.503 | 0.972 | 3 | 79 | 0.39 |
| | | 318 | 0.985 | 20 | 0.0010 | 0.1667 | 0.959 | 11.3 | 0.635 | 0.984 | 164 | 13 | 0.05 |
| Populus | Pb | 293 | 0.986 | 250 | 0.0012 | 0.0943 | 0.0997 | 1.05 | 0.633 | 0.975 | 62 | 173 | 0.09 |
| | | 318 | 0.981 | 500 | 0.0019 | 0.0617 | 0.996 | 4.28 | 0.551 | 0.969 | 2 | 266 | 0.51 |
| | Cu | 293 | 0.979 | 12 | 0.0014 | 0.1064 | 0.981 | 4.82 | 0.476 | 0.852 | 44 | 8 | 0.11 |
| | | 318 | 0.993 | 32 | 0.0030 | 0.0526 | 0.974 | 0.24 | 0.198 | 0.956 | 2 | 7 | 0.56 |
| | Cd | 293 | 0.978 | 23 | 0.0015 | 0.1176 | 0.991 | 3.78 | 0.528 | 0.954 | 106 | 16 | 0.07 |
| | | 318 | 0.998 | 111 | 0.0091 | 0.0215 | 0.934 | 3.10 | 0.467 | 0.994 | 1 | 96 | 0.67 |

Energy obtained from the adsorption of metal ions by the adsorbents; also show that the absorption is physically done [4].

## 3- CONCLUSIONS

By comparing the correlation coefficients of three isotherms, found that Langmuir model has the maximum efficiency and Freundlich and Dubinin-radushkevich, respectively, are next in order. According to thermodynamic constants, the absorption of metals by Populus is endothermic process and an increase in temperature can increases the absorption capacity. However, this is exothermic process for Thuja and therefore, the capacity will be reduced by increasing in temperature.

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