THE ADSORPTION OF HEAVY METALS ON MORINGA OLEIFERA SEED AND SEED CAKE FROM DIFFERENCE SOURCES

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Abstract: The research on the development of natural adsorbents from biowastes has been continuously carried on as one of the alternative ways for decreasing pollution from environment. The adsorption of heavy metal on the seed and seed cake of *Moringa oleifera* from local species and African species had been studied. The adsorption experiment was set up in batch series by varying concentration, contact time, dosage with in different metal concentration of Pb(II), Cd(II), and Cu(II) ions in aqueous solution at pH 4-5. The efficiency of heavy metals adsorption were quantitatively analyzed by Flame Atomic Absorption Spectrophotometer. The result was found that Pb(II) and Cd(II) ions were uptaked by local seed up to 99 and 93% while Cu(II) ions was adsorbed about 85% in 10 minutes. However the seed from African species was shown slightly lower adsorption than the seed from local species particularly for Cd(II) ions. Consequently, it was found that the adsorption of the local seed cake showed higher adsorption than the African species seed cake. In addition, the results obtained from the adsorption isotherm studies of the three metal ions in aqueous solution at optimized condition, contact time of 10 min, biosorbent dose of 1.0 g in 50 mL of each metal ions concentration 100 mg L^{-1}, pH 4-5 and temperature 30°C by analyzed in two adsorption models of Langmuir and Freundlich isotherms equations, indicated a favorable adsorption of three metal ions on the adsorbents through physical adsorption phenomena.

Introduction: *Moringa oleifera* or Maroom is a Thai common vegetable, spices, herbs, condiments, and sometimes as medicine as a source of nourishment for the Thai people since the ancient time (1). Many studies have been focus on the use of Moringa seed and seed cake as coagulant for removal color and turbidity from water (2,3) or as a fertilizer. The removal of heavy metal in the environment is still required continuous development by biosorption process (3,4,5). The sorption of metals by natural material and agricultural waste might be attributed to the presence of polar functional groups of lignin, proteins, carbohydrates, and phenolic compounds that have carboxyl, hydroxyl, sulfate, phosphate, and amino groups. These groups have the ability to bind heavy metals by coordination to form complexes with the metal ions in solution (5). The main objective of this study is the removal of heavy metal ions: Pb(II), Cd(II), and Cu(II) in aqueous solution by comparing the adsorption of biosorbents, *Moringa oleifera* seed from local species(TS), seed from African species(AS), which have higher oil content than that of local species about 10%, and their seed cakes (TSC and ASC respectively) from cold pressing product, as biowaste. The study of adsorption isotherm was also done to indicate their adsorption behavior.

Methodology:
1. Preparation of biosorbents**:** dry *Moringa oleifera* from local seed, African seed and their seed cakes were ground to get fine powder with the particle size approximately 250 µm.
2. The experimental conditions to compare the batch sorption capacity:
   2.1 Place 1.0 g each of biosorbents, *dry Moringa oleifera* seed and seed cake powder in

50 mL of metal ions Pb(II), Cd(II), and Cu(II) solution with concentration varying, 100, 200, 300, 400, and 500 mg L^{-1} respectively.

2.2 Shake the solution to determine the sorption capacity at 1, 2, 5, 10, 15, 20, 30 and 40 minutes. The experiment condition was at pH 4-5 and isotherm temperature 30°C.

2.3 The final concentration of metal ions in solution were filtered and detected by Flame Atomic Absorption Spectrophotometer to calculate the percentage of metal ions uptake by each biosorbent had been computed (1) using the equation

$$\% \text{ adsorption} = [(C_o - C_f)/C_o] \times 100$$

where C_o and C_f are the initial and final (residual) concentration of metal ions in the solution in mg L^{-1} at each concentration and adsorption time.

2.4 To compare the amount of metal ions adsorbed at equilibrium (6) in milligram per unit gram of each biosorbents (q_e).

$$q_e = [(C_o - C_e)V]\ m^{-1}$$

where C_o and C_e are the initial and equilibrium concentration of metal ions in the solution in mg L^{-1}, m the amount of adsorbents in gram, V the volume of metal ion concentration respectively.

2.5 Study the adsorption isotherm for the adsorption capacity of adsorbents for the removal of metal ions at the optimum condition. Two parameter equation isotherms; Langmuir and Freundlich isotherms are applied as follow:

Langmuir isotherm used is:

$$q_e = \frac{Q_m b C_e}{1+bC_e} \quad \text{or} \quad C_e/q_e = 1/Q_m b + C_e/Q_m$$

where C_e (mmol L^{-1}) and q_e (mmol g^{-1}) are the equilibrium concentrations of metal ions in the liquid and solid phases, respectively, Q_m and b are Langmuir constants, Q_m is the maximum metal uptake (mmol g^{-1}) where as b is sorption equilibrium constant (L g^{-1})

Freundlich isotherm use is:

$$q_e = k_f C_e^{1/n} \quad \text{or} \quad \log q_e = \log k_f + 1/n \log C_e$$

where q_e and C_e are the equilibrium concentrations of metal ions in the adsorbed and liquid phase in mmol g^{-1} and mmol L^{-1}, respectively, k_f and n are the Freundlich constants

Results, Discussion and Conclusion:

1. Effect of contact time: The biosorbent process were studied the contact time in the range from 1 to 40 minutes at pH 4-5 and isotherm temperature 30°C with fixed the biosorbent dose of 1.0 g. The results show the rapid increase from 1 min to equilibrium in 10 min of both seeds and seed cakes for those three metal ions adsorption: Pb(II) and Cd(II) ions were rapidly uptaked by seed from local species up to 99% and 93% adsorption while Cu(II) ion was lower adsorbed not more than 85%. However, the seed from African species was shown slightly lower adsorption than the local seed particularly for Cd(II) ions (72%). Consequently, it was found that the adsorption of the local species seed cake showed higher adsorption than the African species seed cake.

2. Effect of initial concentration: The amount of three metal ions adsorbed at equilibrium in milligram per unit gram of each biosorbents (q_e) by varying the initial metal ions concentration as shown in Figure 1-3. The value of q_e increased with higher initial metal ions

concentration because of increasing in the driving force of the concentration gradient but the optimized initial concentration was 100 mgL^{-1}(1). And Pb(II) ion was the better affinity with four adsorbents than Cd(II) and Cu(II).

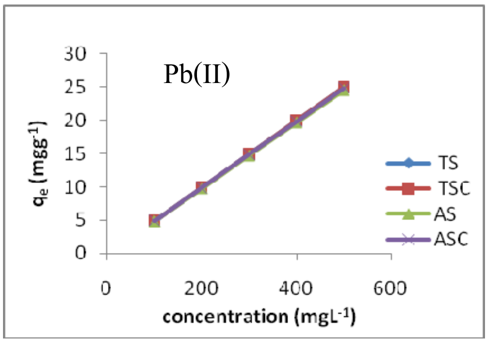

Figure 1 Adsorption capacity (mg g^{-1}) of Pb(II) ions on seed from local species (TS) and local seed cake (TSC), African species seed (AS) and African seed cake (ASC).

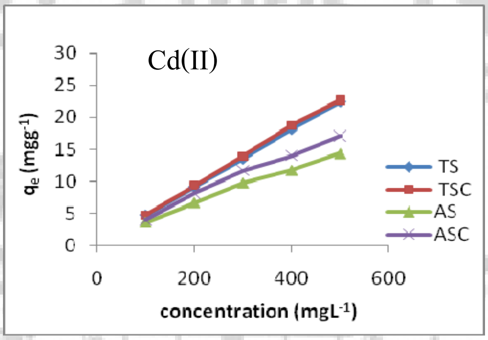

Figure 2 Adsorption capacity (mg g^{-1}) of Cd(II) ions on seed from local species (TS) and local seed cake (TSC), African species seed (AS) and African seed cake (ASC).

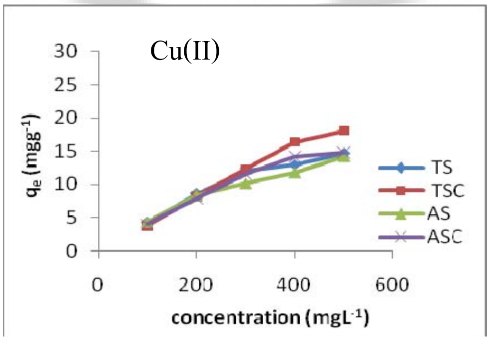

Figure 3 Adsorption capacity (mg g^{-1}) of Cu(II) ions on seed from local species (TS) and local seed cake (TSC), African species seed (AS) and African seed cake (ASC).

3. The adsorption isotherms are important criteria to optimized the nature of interaction between metal ions and the adsorbents. Thus the equilibrium data is useful for the operation of adsorption systems. The results obtained the equilibrium isotherm of Pb(II). Cd(II) and Cu(II) ions were analysed in Langmuir and Freundlich isotherm models. The Freundlich isotherms are presented in Table 1 and Figure 4-7 showed better fit compared to Langmuir isotherm model, due to the value of R^2 was in the acceptable range and n value between 0 and 10 indicates a favorable adsorption (6) of these metal ions on the biosorbents.

Table 1 Freundlich isotherms constants for Pb(II). Cd(II) and Cu(II) ions on the adsorbents.

	R^2	K_f (mg g^{-1})	n
Pb(II)			
TS	0.9883	7.44	0.85
TSC	0.8126	9.96	0.49
AS	0.8998	2.2	0.95
ASC	0.9727	4.29	0.86
Cd(II)			
TS	0.9865	1.34	1.34
TSC	0.9695	9.01	9.01
AS	0.9880	2.45	2.45
ASC	0.9324	6.12	6.12
Cu(II)			
TS	0.8472	1.75	4.12
TSC	0.8429	3.14	2.01
AS	0.9225	1.79	3.93
ASC	0.7657	0.66	5.54

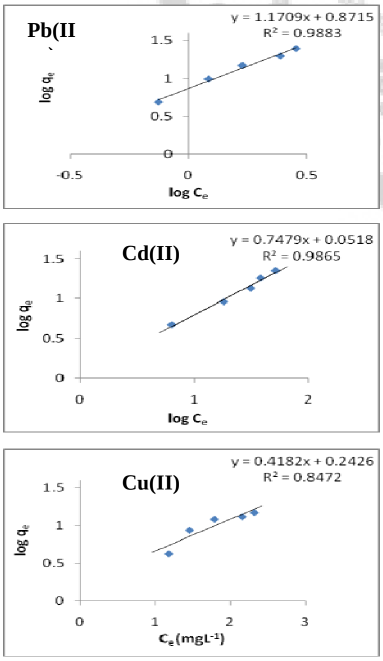

Figure 4 Freundlich isotherm plot for the adsorption of metal ions on TS.

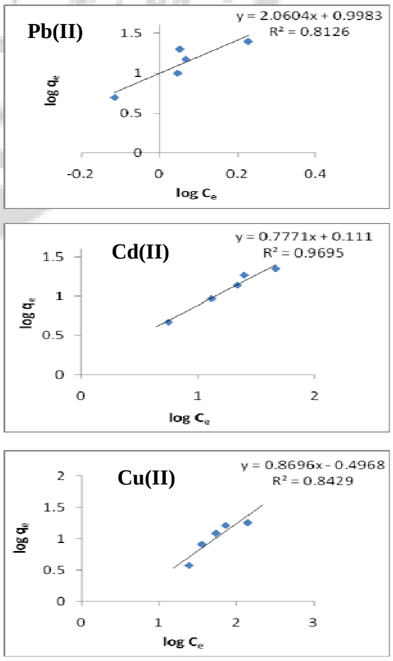

Figure 5 Freundlich isotherm plot for the adsorption of metal ions on TSC.

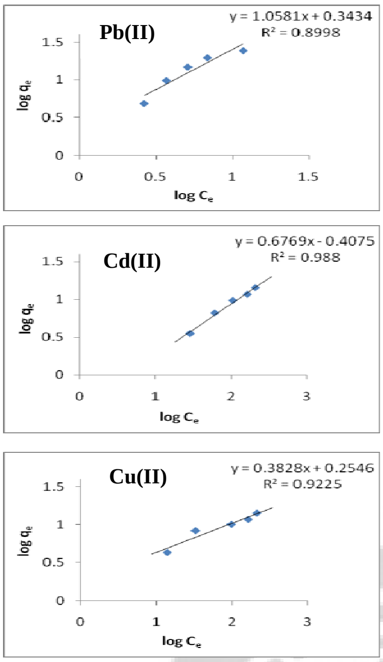

Figure 6 Freundlich isotherm plot for the adsorption of metal ions on AS.

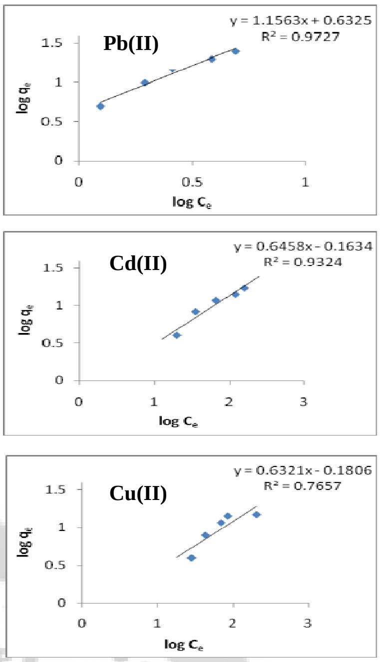

Figure 7 Freundlich isotherm plot for the adsorption of metal ions on ASC.

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