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Evaluation of Adsorption Capacity by Porcelain Made of Palygorskite and Cow Bone to Heavy Metals Ions(Cu^{+2}, Mn^{+2}, and Pb^{+2})

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Abstract

In this study kinematic energy of porcelain made of Palygorskite clay and cow bone. Solutions containing ions of Pb^{+2}, Mn^{+2}, and Cu^{+2}, were prepared at different concentrations (10, 20, 40, 60, and 80)mg/l, to measure the adsorption capacity of the porcelain to these ions. The adsorption capacity were computed according to several kinematic models. The most important models were Langmuir model and Freundlich models. The results showed variety in adsorption capacities for each heavy metal. Results of adsorption capacities according to Freundlich model were: Cu>Mn>Pb. Where maximum capacity was for Cu(3.751*mg/g*), and minimum was for Pb (2.419mg/g). While the results according to Langmuir model were: Pb> Cu> Mn**,** and the capacities were nearly equal for the three ions. They were for Pb (0.891 mg/g), for Cu(0.8165mg/g) and for Mn (0.801mg/g).

Keywords: kinematic, porcelain, Palygorskite, adsorption**.**

Introduction

Removal of heavy metals such as lead, manganese, and copper from aqueous solution is necessary because of the frequent appearance of these metals in waste streams from many industries, including electroplating, metal finishing, metallurgical, tannery, chemical manufacturing, mining textile wastewaters and battery manufacturing. This problem has received considerable attention in recent years, primarily due to the concern that those heavy metals in waste streams can be readily adsorbed by marine animals and directly enter the human food chain, thus presenting a high health risk to consumers [1]. Lead adversely affects red blood cells, the nervous system and the kidneys. Symptoms of manganese poisoning are hallucinations, forgetfulness and nerve damage, also Manganese can cause both toxicity and deficiency symptoms in plants. When the pH of the soil is low manganese deficiencies are more common. Soluble copper compounds form the largest threat to human health. Usually water-soluble copper compounds occur in the environment after release through application in agriculture.

The removal of heavy metal ions from industrial wastes using different adsorbents is currently of great interest. However, in order to minimize processing costs, several recent investigations have focused on the use of low cost adsorbents [e.g. wood-ash [2], cool fly ash [3], biosorbents [4], and tea waste[5] . Adsorbents, mainly clay minerals, are readily available, inexpensive materials and offer a cost-effective alternative to conventional treatment of such mentioned waste streams [6]. Removing of Tartrazine from aqueous solutions using hen feathers [7]. Unmodified and EDTA-modified maize cobs were used to adsorb Cd (II), Pb (II) and Zn (II) ions from aqueous [8]. Atrazine was adsorbed by sheanut shells acid activated [9]. Some kinds of porcelain made of adsorbent materials are used to adsorb many heavy metal ions from their aqueous [10].

Generally, this research aims to study the adsorption ability of porcelain made of local materials.

Material and Methods

Preparing raw materials and producing porcelain

The porcelain raw materials that are used in this study are Palygorskite and Cow Bone, Porcelanite, and Limestone. They were provided by General Company of Geological Surveying and Mineralization.

Cow bones powder were used to produce porcelain bodies. It has flux properties because they composed of $(Ca_3PO_4)_2$[11, 12, 13, 14and 15]. It contains combustible materials due to oils and organic matters inside them. It was cleaned carefully. Then, the bones were milled and screened to the same grade of the other materials used in the production.

The used porcelain was prepared mainly from cow bone in the porcelain mixture. The mixture contains 50 %of cow bone plus 50 %of(Palygorskite, Porcelanite, and Limestone).

Mixtures were prepared by semi dried compressing method. They were burned at 1200 C°.

Porcelains tests

Tests were carried out to examine the properties of the produced porcelain discs. The main properties which were measured were apparent density, porosity, water absorption, and hydraulic conductivity. They were measured according to ASTM-C373 Standards [16].

Adsorption ability was measured for produced porcelain. The test was carried out passing polluted water through porcelain discs, which were produced for measuring the porcelain properties, and measuring the concentration of pollution before and after passing. The polluted water was prepared at laboratory. 500 *mg/l* standard stock solutions of Pb^{+2}, Mn^{+2}, and Cu^{+2}were prepared. Make up solutions of these ions at different concentratio1, 10, 20, 40, 60, and 80 *mg/l* of each of these ions. The final concentrations of metal ions in the solution were determined by atomic absorption spectrometer, AAS, for residual ions content.

Adsorption capacity

The adsorption equilibrium data of Pb^{+2}, Mn^{+2}, and Cu^{+2}were fitted to different isotherm models as described in the following paragraphs, to evaluate their suitability for the porcelain.

1. Henry's Law model equation can be given as follows, [17]:

$$q_e = KC_e \qquad (1)$$

Where: q_e= adsorbed amount in equilibrium with respect to the total adsorbents used in adsorption (mg/g).

C_e= concentration of adsorbate on adsorbent at equilibrium (mg/L).

K= Henry' constant.

The slope of the line obtained from qe vs. Ce graph results in K and the adsorption will be 1/K(mg/g).

2. Modified Henry's Law model equation can be given as follows, [17]:

$$q_e = KC_e + m \qquad (2)$$

Where: q_e= adsorbed amount in equilibrium with respect to the total adsorbents used in Adsor ption (mg/g).

C_e= concentration of adsorbate on adsorbent at equilibrium (mg/L).

K, & m= Henry's constants.

These constants can be evaluated from the intercept and the slope of the linear plot of experimental data of q_e versus C_e, respectively. The invers of K will be the adsorption capacity(mg/g).

3. Langmuir represented the following equation, [18]:

$$q_e = \frac{Q_o K_L C_e}{1+K_L C_e} \qquad (3)$$

Langmuir adsorption parameters were determined by transforming the Langmuir equation (3) into linear forms, [18, and 19]:

$$\text{I} \qquad \frac{1}{q_e} = \frac{1}{Q_o} + \frac{1}{Q_o K_L C_e} \qquad (4)$$

$$\text{II} \qquad \frac{C_e}{q_e} = \frac{1}{Q_o b} + \frac{C_e}{Q_o} \qquad (5)$$

Where: C_e = the equilibrium concentration of adsorbate (mg/L^{-1})

q_e = the amount of metal adsorbed per gram of the adsorbent at equilibrium (mg/g).

Q_o = maximum monolayer coverage capacity (mg/g)

K_L = Langmuir isotherm constant (L/mg).

These constants can be evaluated from the intercept and the slope of the linear plot of experimental data of $1/q_e$ versus $1/C_e$ for linear form I.

While for linearization form II the slope and intercept of the line obtained from C_e/q_e vs., C_e graph resulted in Q_o and b constants, respectively.

4. Freundlich isotherm model can be illustrated as Equation (6), [20]:

$$q_e = K_F C_e^{1/n} \qquad (6)$$

The linear form of Freundlich isotherm could be done as following, [21]:

$$\log q_e = \log K_F + \frac{1}{n} \log C_e \qquad (7)$$

Where: $K_{F=}$ adsorbent capacity(mg/g).

n= Freundlich constant being heterogeneity factor.

The slope of the line obtained from log qe vs. log C_e graph results in 1/n and its intercept results in log K_F.

5. Dubinin–Radushkevich isotherm is represented by the equation below, [9]:

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$$q_e = q_D \exp(-B_D [RT \ln(1+\frac{1}{C_e})]^2) \qquad (8)$$

Equation D-R isotherm was linerized as follow:

$$\ln qe = \ln q_D - 2B_D RT \ln (1 + 1/Ce) \qquad (9)$$

where: $q_{D=}$ the isotherm constant, theoretical isotherm saturation capacity (mg/g) , [22]:

R= the gas constant (8.314 J/mol K).

T = absolute temperature (K).

C_e= adsorbate equilibrium concentration (mg/L).

The plots of In q_e against RT In (1 + 1/C_e), yielded straight lines and indicates a good fit of the isotherm to the experimental data. The values of q_D and B_D calculated from the intercepts slopes of the plots respectively.

Results and discussion

The results of physical properties tested (apparent density, porosity, true porosity, water absorption, and hydraulic conductivity), were: 1.14 gm/cm^3, 53.44%, 13.1%, 46.98%, and 0.0075 m/hr respectively.

The results of adsorption ability showed that produced porcelain had adsorbed most of the heavy metals ions. The removal of Cu^{+2}, Mn^{+2}, and Pb^{+2} were: 99.8, 99.30, and- 100% respectively of the initial concentration 1 mg/l.

the adsorption capacity of the porcelain were evaluated by several isotherms models as indicated before. Figs. 1,2,3,4, 5, and 6, showed the linear plots of the used isotherm models for adsorption of Cu^{+2} data. The data were best fitted with Langmuir I, and Freundlich because they had the highest regression factors which tends to one(0.9947 and 0.9914) respectively. Table 1 showed the results of linear plot for the adsorption capacity of the produced porcelain for Cu^{+2}, Mn^{+2}, and Pb^{+2}. Results of adsorption capacities according to Freundlich model were: Pb> Cu> Mn, and the capacities were nearly the same for three ions (0.8910- 0.8165 and 0.8014mg/g) respectively. While the results according to Langmuir model were: Cu> Mn> Pb, and the capacities were: 3.7509, 2.792, and 2.4189 mg/g respectively.

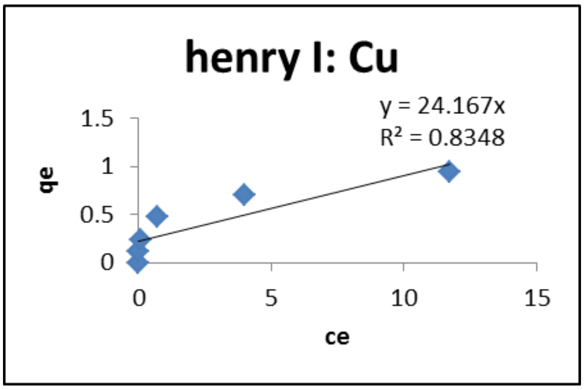

Fig 1: Henry I isotherm graph.

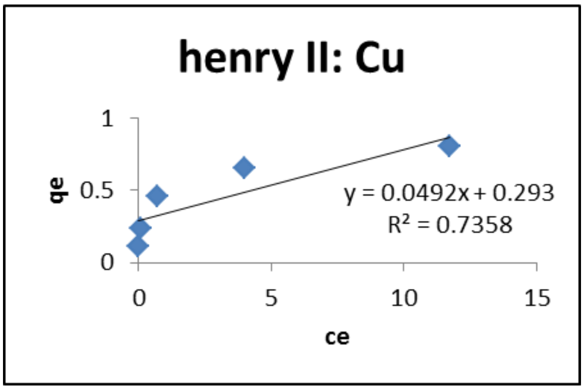

Fig 2: Henry II isotherm graph.

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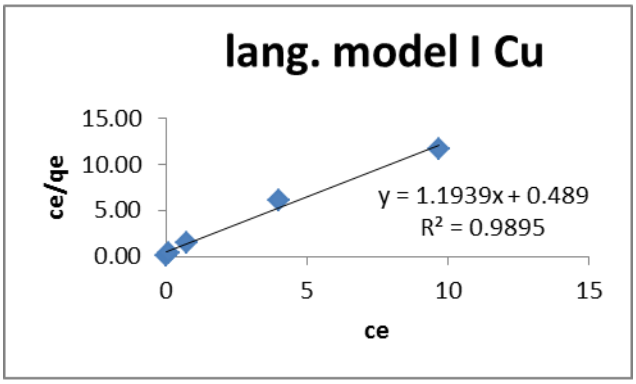

Fig 3: Langmuir I isotherm graph.

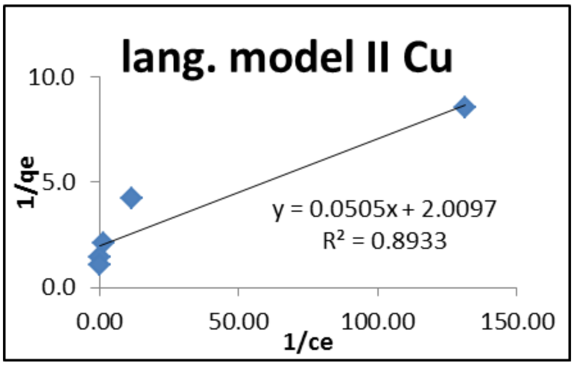

Fig 4: Langmuir II isotherm graph.

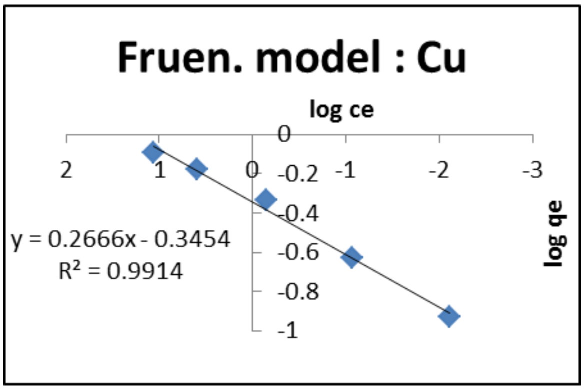

Fig 5: Frundlich isotherm graph.

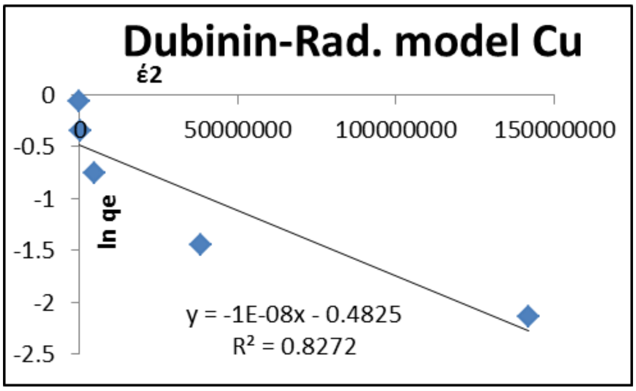

Fig 6: Dubinin- Rad isotherm graph.

Table 1: The results of linear plot for the adsorption capacity of the produced porcelain for Cu^{+2}, Mn^{+2}, and Pb^{+2}.

Metal ion	Adsorption capacity (mg/g) (Henry model I)	R^2	Adsorption capacity (mg/g) (Henry model II)	R^2	Adsorption capacity (mg/g) (Langmuir model I)	R^2	Adsorption capacity (mg/g) (Langmuir model II)	R^2	Adsorption capacity (mg/g) (Freundlich model)	R^2	Adsorption capacity (mg/g) (Dubinin-Radushkevuch model)	R^2
Mn	24.331	0.7216	28.169	0.7408	0.8014	0.9802	1.903	0.9437	2.792	0.9796	0.5281	0.8124
Cu	0.0413	0.8348	20.408	0.7358	0.8376	0.9895	19.8015	0.8933	3.7509	0.9914	0.6172	0.8272
Pb	15.5038	0.7779	17.667	0.8052	0.8910	0.9894	1.8288	0.9147	2.4189	0.9773	0.5351	0.7581

Conclusion

The following can be concluded from the research:

1) Porcelain made of Palygorskite and Cow bone was produced to water treatment.
2) This porcelain has high hydraulic conductivity 0.0075 *m/hr* .
3) The adsorption ability of the porcelain for heavy metal ions (Cu^{+2}, Mn^{+2}, and Pb^{+2}) were measured.
4) The adsorption capacities were evaluated by isotherm models:
    a. Henry model I, and II.
    b. Langmuir model linearization I, and II.
    c. Freundlich model linearization I, and II.
    d. Dubinin- Radushkevich mode.
5) The adsorption experiments data were fit with Langmuir and Freundlich models because they had the highest regression factors (R^2).
6) Adsorption capacities according to Freundlich model were nearly the same for heavy metal ions (Cu^{+2}, Mn^{+2}, and Pb^{+2}). They were (0.8910-0.8165and 0.8014mg/g).
7) Langmuir model adsorption capacities were: Cu> Mn> Pb, and the capacities were: 3.7509, 2.792, and 2.4189 mg/g respectively

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