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EFFECT OF THE MASS OF ZEOLITE IN CURCUMIN SOLUTION ON THE ADSORPTION PROCESS MEASURED WITH LUXMETER

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ABSTRACT

The purpose of this study was to show the effect of the mass of zeolite in curcumin solution on the adsorption process as measured by a luxmeter. Adsorption research using the batch system method is carried out with a number of Erlenmeyer glasses containing a solution containing certain substances to be adsorbed at a certain volume. Zeolite was used as an adsorbent with a size of 0.2 cm and a mass variation of 0.2; 0.4; 0.6; and 0.8 grams. Turmeric solution was specified as a model dye and this solution was linked to a commercially available zeolite. Then the measurement results are compared with several adsorption isotherm models, such as: Langmuir, Freundlich, Temkin, Dubinin-Radush kevich, Jovanovic, Harkin-Jura, and Halsey models. As for the results showed that the zeolite can absorb dye, and the isotherm model has a linearity parameter of R^2 above 80%. The absorption and diffusion properties of zeolite are caused by the presence of different canal sizes and various cavities, because of which zeolite can also absorb dye from the turmeric solution. With this research, we gain experience and understanding of the concept of adsorption, it is hoped that it can also be applied in water and air purification.

Keywords: zeolite, adsorption, turmeric solution

INTRODUCTION

Adsorption is the process of clumping of substances dissolved in solution by the surface of the adsorbent and results in the entry of material which then collects in an absorbent substance. There are also those who call it adsorption, because they often appear together with a process. In adsorption there are called adsorbent and adsorbate. Adsorbent is an absorbent substance, in contrast to adsorbate which means the substance that is absorb (Giyatmi, 2008). Solid substances that can absorb certain components of a fluid phase are called adsorbents. Adsorbents generally use materials that have pores, which serve as a place for this to occur, this can also occur in specific locations on the particle. Usually, the pores that are still present in the adsorbent are very small. As a result, the inner surface is wider than the outer surface. Separation occurs due to differences in molecular weight or polarity which results in some molecules inherent in the surface more tightly than others (Saragih, 2008).

Zeolite is one of the adsorbents in the form of a mineral group which is the result of a hydrothermal process. SiO2 and Al2O3 are the main forming units that build this zeolite mineral structure. Where, SiO2 and Al2O3 which form a tertrahedral when each oxygen atom is at the four corners. Zeolites have a main skeletal structure occupied by silicon or aluminum atoms with four oxygen atoms at each corner. This zeolite structure is the active site of the zeolite, causing the zeolite to have the ability as an adsorbent (Kundari, 2008).

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Research on the use of natural zeolite as an adsorbent has been widely carried out and is shown in table 1, some of which include research that has been carried out (Sumarli et al, 2016) which shows that the treatment of factory wastewater in animal feed by varying the amount of zeolite mass through filtration media can increase treated water quality. Zeolite has adsorbent properties that are often applied to ethanol purification as previously conducted by (Nais, MF and Wibawa, G., 2011) where in improving the quality of Indonesian natural zeolite bioethanol fuel grade which shows modified natural zeolite products (addition of sodium aluminate in NaOH solution and calcination) to be used as the adsorption of water in the ethanol-water mixture and then increased adsorption capacity amounted to 16.57% when compared to the pure natural zeolite, good in separating a mixture of ethanol-water on condition azeotrope. Research (Novitasari *et al*, 2012) purification of bioethanol using adsorption and distillation adsorption processes with an optimization of 50 minutes and a heating temperature of 78°C using a zeolite adsorbent that has been activated at a temperature of 300°C can increase the purity level of bioethanol from 80% to 98.42 % (higher) more economical. Study of modification and characterization of natural zeolite from various countries which are researches (Lestari, 2010) shows that natural zeolite is cheaper. In addition, (Ngapa, YD and Ika YE, 2020) in their research showed natural zeolite as an effective and efficient adsorbent to overcome pollution caused by methylene blue and methyl orange dyes, and other studies are shown in **table 1**.

Table 1. Materials and Disadvantages of Applying Zeolite

No	Researcher	Material topic	Profit	Loss	Reference
1.	Sumarli, Ian Yulianti, Masturi, Rosyidatul Munawaroh	Effect of Zeolite Mass Variation on Animal Feed Factory Wastewater Treatment through Filtration Media	The results showed that the treatment of animal feed factory wastewater by varying the mass of zeolite through filtration media could improve the quality of the treated water.	This research is only limited to the effect of variation zeolite mass on the filtration media against parameter Ting water clarity, TDS and pH of wastewater.	(Sumarli et al., 2016)
2.	M. Furoiddun Nais, Gede Wibawa	Improving the Quality of Indonesian Natural Zeolite as an Adsorbent in the Production of Bioethanol Fuel Grade	Utilization in the production of fuel grade bioethanol, synthetic zeolite has an important role, in which the synthetic zeolites of type A is used as an adsorbent to water, which can separate a mixture of ethanol-water on condition azeotrope.	However, the use of synthetic zeolite for water adsorption in ethanol purification has problems due to the high price.	(Nais and Wibawa, 2011)

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No	Researcher	Material topic	Profit	Loss	Reference
3.	Dewi Novitasari and Djati Kusumaningrum	Purification of Bioethanol Using Adsorption and Distillation Process Adsorption with Zeolite Adsorbent	A simple and more economical method to obtain ethanol with higher purity is by adsorption distillation with a zeolite adsorbent.	-	(Novitasari and Kusumaningrum, 2012)
4.	Dewi Yuanita Lestari	Study of modification and characterization of natural zeolite from various countries	This study aimed to study the natural zeolite modification and characterization of various countries because of natural zeolite is a zeolite that is mined directly from nature thus the price is much more inexpensive than the zeolite synthetic.	This study has a disadvantage because natural zeolite has several weaknesses, including many impurities and poor crystallinity.	(Sustainable, 2010)
5.	Yulius Dala Why, Yasinta Embu Ika	The Potential of Ende Natural Zeolite As A Competitive Adsorbent Media For Methylene Blue And Methyl Orange Colorants	Natural zeolite is used as an alternative effective and efficient adsorbent to overcome pollution caused by methylene blue and methyl orange dyes	Natural zeolite has a large Si/Al ratio but still contains impurities in the form of metal oxides thus the surface area is low.	(Napa and Ika, 2020)
6.	Ahmad Yamliha, Bambang Dwi Argo, Wahyunanto Agung Nugroho	The Effect of Zeolite Size on Carbon Dioxide (CO_2) Absorption on Biogas Stream	As an alternative energy fuel and has a fairly cheap price compared to ordinary fuel.	The selected zeolite must have 60 mesh particles to have a more optimal effectiveness than 5 mesh and 16 mesh particle zeolite because the particle size is smaller and has a large surface area, thus the absorption is greater.	(Yamliha, Argo, and Nugroho, 2013)

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No	Researcher	Material topic	Profit	Loss	Reference
7.	Setyo Purwoto and Joko Sutrisno	Groundwater Treatment Based Treatment Ferrolite, Manganese Zeolite and Ion Exchange	for lower some parameters of clean water in water land, which is useful for improve ground water quality.	-	(Purwoto and Sutrisno, 2016)
8.	Nevi Dwi Andari and Sri Wardhani	TIO2-Zeolite Photocatalyst For Methylene Blue Degradation	To overcome the dye waste by the photodegradation method	Long irradiation is quite time consuming but affects the photodegradation process.	(Andari and Wardhani, 2014)
9.	Is Fatimah, Eko Sugiharto, Karna Wijaya, Iqmal Tahir, and Kamalia	Dispersed Titan Dioxide in Natural Zeolite (TiO_2/Zeolite) and Its Application for Photodegradation of Congo Red	Utilization of the technique of making natural zeolite photocatalyst modified by titan dioxide to degrade Congo Red dye. The photocatalyst is made using the titan mechanical dispersion technique dioxide into the pores and the surface of the natural zeolite followed by calcination at high temperature.	It takes an hour to degrade approximately 40% Congo Red photocatalytically by system TiO2/zeolite and UV light.	(Fatimah et al., 2006)
10.	Muhammad Said, Arie Wagi Prawati, Eldis Murenda	Activation of Natural Zeolite as an Adsorbent in Iodine Solution Adsorption	Analysis of the active zeolite was carried out by testing the absorption capacity of the iodine solution in batches and continuously.	Further research is needed on continuous adsorption by increasing the flow time until the zeolite saturation point is reached, thus it can be applied in industry.	(Said et al., 2008)

But in general, in these studies there are disadvantages:

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1. Limited to the effect of variations in the mass of zeolite on the filtration media on the parameters of water clarity, TDS and pH of wastewater
2. The price of materials for synthesizing zeolite is quite high
3. Natural zeolite contains a lot of impurities and the crystallinity is not good.

In contrast to other studies based on **table 1**, no one has examined the effect of mass variations of zeolite in turmeric solution on the adsorption process.

Therefore, this study was conducted with the aim of showing the effect of the mass of zeolite in turmeric solution on the adsorption process as measured by a luxmeter. Where the adsorption test uses the batch system method, which is carried out with a number of glasses/bottles containing a solution containing a turmeric solution which adsorbed at a certain volume. A number of adsorbents with varying weights are added to each glass. Furthermore, the solution and adsorbent in the glass are stirred for a certain time and after that the adsorption process is analyzed/measured (Masduqi & Slamet, 2000). The adsorption process was analyzed/measured with the help of a flashlight and a luxmeter.

In this case, the experimental results are then applied to the adsorption isotherm equation, namely: Langmuir, Freundlich, Temkin, Dubinin-Raduskevich, Florry-Huggins, Fowler-Guggenheim, Hill-Deboer, Jovanovic, Harkin-Jura, and Hasley. The measurement results have a great impact on students' understanding, where they have a better understanding of the adsorption concept compared to conventional teaching methods. Informing the results of experimental tests with several variations in the mass of zeolite in turmeric solution has a significant impact on the adsorption process, thus it can also be applied in water and air purification.

ADSORPTION ISOTERM THEORY

1. Langmuir isotherm

Langmuir isotherm defines that the maximum adsorbent capacity occurs due to the presence of a single layer (monolayer) of adsorbate on the surface of the adsorbent. There are four assumptions in this type of isotherm, namely (Langmuir, 1918):

a. Molecules are adsorbed by fixed sites (reaction sites on the adsorbent surface).
b. Each site can "hold" one adsorbate molecule.
c. All sites have the same energy.
d. There is no interaction between the adsorbed molecule and the surrounding sites.

The adsorption process forms a monolayer. Illustration of monolayer formation during adsorption is shown in **Figure 1(a)**. Langmuir isotherm model is represented by **equation (1):**

$$\frac{1}{Q_e} = \frac{1}{Q_{max} K_L C_e} + \frac{1}{Q_{max}} \qquad \textbf{(1)}$$

Where *Qe* is the number of adsorbate molecules per gram of adsorbent (mg/g), *Q max* is the capacity of the monolayer adsorbent (mg/g), *Ce* is the adsorbate the equilibrium concentrations (mg / L), and *K L* is the Langmuir adsorption constants. An important factor in the Langmuir isotherm is the dimensionless constant or the separation factor (*RL*) (Langmuir, 1918), which is expressed by **equation (2):**

$$R_L = \frac{1}{1 + K_L C_e} \qquad \textbf{(2)}$$

This separation factor has the following values:

(i) *R L > 1*, the adsorption process is not profitable (allowing the adsorption process occurs, most of the desorption process occurs).
(ii) *R L = 1*, the adsorption process is linear (depending on the amount adsorbed and the concentration absorbed).

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(iii) $R_L = 0$, the adsorption process is irreversible (strong absorption).
(iv) $0 < R_L < 1$, Favorable adsorption process (normal absorption)

2. Freundlich isotherm

The Freundlich isotherm describes the physics of the type of adsorption in which the adsorption occurs in several layers and the bond is not strong (in layers). The multilayer formation is illustrated in **Figure 1(b)**. The Freundlich isotherm also assumes that the sites of adsorption are heterogeneous (Dada *et al.,* 2012). The empirical relationship for expressing the Freundlich isotherm is given in **equation (3):**

$$\ln Q_e = \ln K_f + \frac{1}{n} \ln C_e \tag{3}$$

where *Kf* is Freundlich's constant, *Ce* is the adsorbate concentration under equilibrium conditions (mg/L), *Qe* is the amount of adsorbate absorbed per unit adsorbent (mg/g), and is a value indicating the degree of linearity between adsorbate solution and adsorption process (Dada *et al.,* 2012). The value of *n* is described as follows:

(i) = 1, linear adsorption.
(ii) < 1, the adsorption process with chemical interactions.
(iii) > 1, the adsorption process with the physics of interaction.
(iv) A favorable adsorption process is expressed when 0 < 1/ *n* < 1, and a cooperative adsorption process occurs when 1/ *n* > 1.

3. Temkin isotherm

The main isotherm assumes three postulates, namely that the heat of adsorption decreases linearly with increasing surface coverage of the adsorbent, the adsorption process assumes a uniform binding energy distribution on the surface of the adsorbent, and the adsorption interaction involves the interaction between the adsorbate-adsorbent (Romero-Gonzales *et al.,* 2005). The termkin isotherm is given in **equation (4)**

$$Qe = BT \ln AT + BT \ln Ce \tag{4}$$

Where *BT* is the heat constant of adsorption (if the *BT* < 8 kJ/mol, the adsorption process occurs physically), *AT* is the binding equilibrium constant, and *T* is the absolute temperature.

4. Dubinin-Radushkevich Isotherm

The Dubinin-Radushkevich isotherm states the adsorption process on the adsorbent having a pore structure or an adsorbent having a heterogeneous surface and expressing the free energy of adsorption. Its adsorption process is based on micropore filling volume (Romero-Gonzales *et al.,* 2005). The Dubinin-Radushkevich isotherm is written in **equation (5):**

$$\ln Qe = \ln Qs - (\beta \varepsilon^2) \tag{5}$$

Where is the Dubinin-Radushkevich isotherm constants, Q_s refers to the saturation capacity of the theoretical isotherms, and $\mathcal{E}$ is Polanyi Potential (J / mol) is calculated using **equation (6):**

$$\varepsilon = RT \ln \{1 + \frac{1}{Ce}\} \tag{6}$$

To calculate the adsorption free energy per adsorbate molecule, it is calculated using **equation (7):**

$$E = \frac{1}{\sqrt{2\beta}} \tag{7}$$

Where *Ce* is the equilibrium concentration of the solute and *E* is the energy of the adsorbate per molecule as the energy required to remove molecules from the surface. The equation explains:

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(i) $E < 8$ kJ/mol, physical adsorption.
(ii) $8 < E < 168$ kJ/mol, chemical adsorption.

5. Jovanovic Isotherm

The Jovanoic isotherm is based on the assumptions found in the Langmuir model, without allowing some mechanical interaction between the adsorbate and adsorbent (Ayawei et al., 2017). The linear correlation of the Jovanovic model is shown in **equation 8** :

$$\ln Q_e = \ln Q_{max} - K_J C_e \qquad \textbf{(8)}$$

Where Qe is the amount of adsorbate in the adsorbent at equilibrium (mg/g), Q_{max} is the maximum adsorbate absorption, and K_J is the Jovanic constant.

6. Halsey

The Halsey isotherm evaluated the multi-layer adsorption system (Dada *et al.,* 2012). Halsey's model follows **equation (9):**

$$Q_e = \frac{1}{n_H} \ln K_H - \left(\frac{1}{n_H}\right) \ln C_e \qquad \textbf{(9)}$$

Where K_H and n are Halsey's model constants

7. Harkin-Jura Isotherm

The Harkin-Jura isotherm explains that the adsorption that occurs on the surface of the adsorbent is a multilayer adsorption because the adsorbent has a heterogeneous pore distribution (Ayawei et al., 2017). This model can be expressed by **equation 10** :

$$\frac{1}{q_e^2} = \frac{\beta_{HJ}}{A_{HJ}} - \left(\frac{1}{A}\right) \log C_e \qquad \textbf{(10)}$$

With the value of $ß_{HJ}$ related to the surface area of the adsorbent and A_{HJ} are constants Harkim Jura. The modification of the Harkin Jura equation above can be used to determine the surface area of the adsorbent. So the formula can be modified again into **equation 11** :

$$\beta_{HJ} = \frac{-q(s^2)}{4.606RTN} \qquad \textbf{(11)}$$

Where *q is the* constant of the adsorbent, S is the specific surface area $\left(\frac{m^2}{g}\right)$, R is the universal gas constant (8.314$\frac{J}{mol/K}$), T is the temperature, and N *is* Avogadros' number. Then the specific surface area of the adsorbent can be determined by **equation 12** :

$$S^2 = -\frac{\beta_{HJ} \times 4.606RTN}{q} \qquad \textbf{(12)}$$

8. Florry-Huggins Isotherm

Flory-Huggins isotherm takes into account the degree of surface coverage of the adsorbate on the adsorbent. This isotherm also assumes that the adsorption process occurs spontaneously (Saadi *et al.,* 2015). Flory-Huggins isotherm is expressed by **equation (13):**

$$\log \frac{\theta}{C_e} = \log \mathrm{KFH} + \mathrm{n} \log(1 - \theta) \qquad \textbf{(13)}$$

where $\theta = (1 - \frac{C_e}{C_o})$ is the degree of surface coverage, *KFH* is the Flory–Huggins model equilibrium constant and *nFH* is the number of adsorbates occupying adsorption site. Furthermore,

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the Gibbs free energy of spontaneity (ΔG^o) is calculated from the equilibrium constant (*KFH*). The value of ΔG^o corresponds to the *KFH* value as shown in **equation (14)**:

$$\Delta G^0 = -RT \ln KFH \qquad (14)$$

The negative sign on the value ΔG^o confirms that the adsorption process is spontaneous, which is a function of temperature (*T*).

9. Fowler-Guggenheim Isotherm

The Fowler-Guggenheim isotherm shows that there is a lateral interaction in a place with weak interaction (Van der Waals interaction effect) between one another (Hamdaoui and Naffrechoux, 2007). The Fowler-Guggenheim isotherm model is expressed by **equation (15)** :

$$\left(\frac{Ce(1-\theta)}{\theta}\right) - \frac{\theta}{1-\theta} = -lnK_{FG} + \frac{2W\theta}{RT} \qquad (15)$$

Where where K_{FG} is a constant, *W* (kJ/mol) for the adsorbed adsorbate indicating the interaction between the adsorbate and adsorbent, *Ce* is the equilibrium constant, *W* is the empirical interaction energy between two molecules adsorbed on the adjacent side (kJ/mol), and is the surface coverage fraction. The empirical interaction energy (*W*) has the following values:

(i) If $W > 0$ kJ/mol, the attractive interactions between the adsorbed molecules
(ii) If $W < 0$ kJ/mol, repulsive interactions between adsorbed molecules
(iii) If $W = 0$ kJ/mol, there is no interaction between the adsorbed molecules

10. Hill-Deboer Isotherm

The Hill-Deboer isotherm describes mobile adsorption and bilateral interactions between the adsorbed molecules (Hamdaoui and Naffrechoux, 2007). The Hill-Deboer isotherm model is written in **equation 16** :

$$ln\left[\frac{Ce(1-\theta)}{\theta}\right] - \frac{\theta}{1-\theta} = lnK_1 - \frac{K_2\theta}{RT} \qquad (16)$$

Where K_1 is a constant Hill-Doeber (L / mg) and K_2 is a constant energy of interaction between the molecules are adsorbed (kJ / mol):

(i) $K_2 > 0$ kJ / mol, the pull between the molecules are adsorbed
(ii) $K_2 < 0$ kJ / mol, repel between the molecules are adsorbed
(iii) $K_2 = 0$ kJ / mol, no interactions between molecules are adsorbed

The quantity adsorbed by the adsorbent mass unit at equilibrium (*Qe*) is calculated using **equation (17)** :

$$Q_e = \frac{C_o - C_e}{m} \times V \qquad (17)$$

the C_o as the initial concentration (mg/L), *Ce* as the concentration at equilibrium (mg/L), *m* as the mass of adsorbent (grams), and *V* as the volume of solution adsorbansi (L).

There is also information about fitting curve data, calculations, and isotherm parameters, as shown in **table 2** below:

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Table 2. Information regarding curve data fitting, calculation, and isotherm parameters

Isotherm Type	Linier Equation	Plotting	Parameter
Langmuir	$\frac{1}{Qe} = \frac{1}{Q_{max}K_L}\frac{1}{C_e} + \frac{1}{Q_{max}}$	1/Ce vs 1/Qe	• $\frac{1}{Qmax} = intercept$ • $Q_{max=} \frac{1}{intercept}$ • $K_L = \frac{1}{Q\max x\ slope}$
Freundlich	$lnQ_e = lnK_f + \frac{1}{n}lnC_e$	ln Ce vs ln Qe	• ln K_F = intercept • K_F = e^{slope} • $\frac{1}{n_f} = slope$ • $n_f = \frac{1}{slope}$
Temkin	$Q_e = B_T lnA_T + B_T lnC_e$	ln Ce vs Qe	• B = slope • ln A_T =$\frac{intercept}{B_T}$ • B_T =$\frac{RT}{B}$
Dubinin-Radushkevich	$lnQ_e = lnQ_s - (\beta\varepsilon^2)$	ε^2 vs ln Qe	• B = K_{DR} = slope • $E = \frac{1}{\sqrt{2\beta}}$
Jovanovic	$\ln q_e = \ln q_{max} - K_J C_e$	Ce vs ln Qe	• K_J = slope • Q max = $e^{intercept}$ • ln Qmax = intercept
Halsey	$q_e = \exp\left(\frac{\ln K_H - \ln C_e}{n_H}\right)$	ln Ce vs ln Qe	• $\frac{1}{n_H}$=slope • $\frac{1}{slope}$ =n_H • ln K_H = intercept • K_h= $e^{intercept}$
Harkin-Jura	$\frac{1}{qe^2} = \frac{\beta_{HJ}}{A_{HJ}} - \frac{1}{A}\log C_e$	logCe vs$\frac{1}{qe\hat{}2}$	• A_H= $\frac{1}{slope}$ • $\frac{BH}{AH} = intercept$
Fowler-Guggenheim	$ln\left(\frac{Ce\,(1-\theta)}{\theta}\right) - \frac{\theta}{1-\theta} = -\ln K_{FG} + \frac{2W\theta}{RT}$	θ vs $ln\left(\frac{Ce\,(1-\theta)}{\theta}\right)$	• W =slope • -ln K_{FG} = intercept • K_{FG} = $e^{-intercept}$ • α (slope) = $\frac{2W\theta}{RT}$ • W =$\frac{RT\alpha}{\theta}$ • θ = 1 – ($\frac{Ce}{Co}$)
Flory Huggins	$\log\frac{\theta}{Co} = \log K_{FH} + nlog\ (1-\theta)$	$\log\frac{\theta}{Co}\ vs$ $log\ (1-\theta)$	• n_{FH}= slope • log k_{FH} = intercept • ΔG^0 = RTln (k_{FH}) • θ = 1 – ($\frac{Ce}{Co}$)
Hill-Doboer	$\ln(\frac{Ce\,(1-\theta)}{\theta}) - \frac{\theta}{1-\theta} = \ln K_1 - \frac{K_2\theta}{RT}$	θ vs $\ln(\frac{Ce\,(1-\theta)}{\theta}) - \frac{\theta}{1-\theta}$	• -ln k_1 = intercept • α (slope) =$\frac{K_2\,\theta}{RT}$ • k_2 = $\frac{RT\alpha}{\theta}$ • θ = 1 – ($\frac{Ce}{Co}$)

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METHODS

1. Ingredient

In this study, the materials used were turmeric powder (Desaku turmeric powder, PT. Motasa, Indonesia), zeolite, water.

2. Adsorption Process

Adsorption testing is carried out with the first step making a series of adsorption test equipment as shown in **figure 1** below :

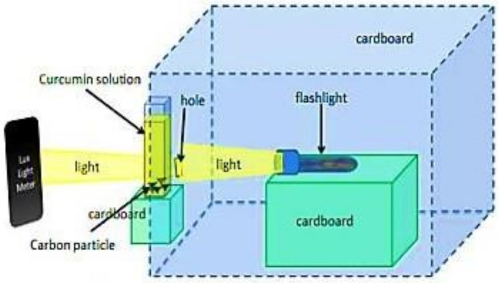

Figure 1. Adsorption test equipment

Continued to make a mother liquor of curcumin/turmeric in 1 bottle consisting of 50 mL of solvent (water) with 1 gram of curcumin/turmeric powder. The curcumin/ turmeric solution was left overnight to form a precipitate. Then the dissolved liquid is separated from the precipitate by decantation, the liquid has a concentration of 100 ppm. Next, dilute the solution resulting from the decantation (100 ppm concentration) to obtain the respective concentrations of 33; 25; 12.5 and 6.25 ppm. All solutions with different concentrations (already diluted) were tested first using a luxmeter before adding zeolite into it, then the results obtained were recorded to make a standard solution. Next, add zeolite to the solution in a different sample bottle. Then each solution in a different sample bottle with variations in zeolite mass was tested using a luxmeter. Don't forget to record the results. The measurement results from the luxmeter are converted into concentrations using the Lambert Beer equation. After the conversion data is obtained, the value of C_0 obtained (conversion of the initial luxmeter measurement results to the value of C_e (conversion of the luxmeter measurement results after adding zeolite). Then this value is entered into several calculation formula models such as Langmuir, Freundlich, and others.

RESULTS

Based on the results of the study obtained data on the relationship between variations in zeolite mass and light intensity, as well as on the clarity of the turmeric solution after the adsorption process. Where the results of the study as shown in **Figure 1** the level of light intensity, after the solution was allowed to stand for ± 8 hours and then measured with a luxmeter, it shows that the higher the mass of the adsorbent, the level of light intensity or in other words the adsorption capacity increase. In increasing the light intensity or adsorption capacity, it can be seen that there are several influencing factors, some of which are mass factors and zeolite contact time. In this case, the presence of an active adsorbent or zeolite associated with the adsorbate causes an increase in adsorption capacity (Silvi, Daud, and Yenti, 2017), thus the level of light intensity also increases. The following graph shows the effect of zeolite mass variation with light intensity or adsorption in the equation model.

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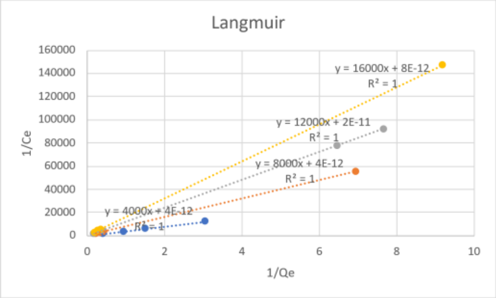

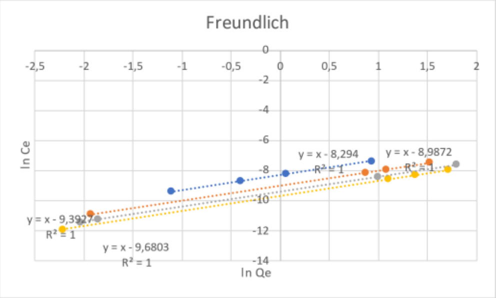

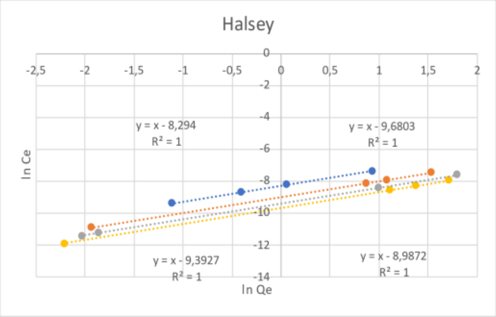

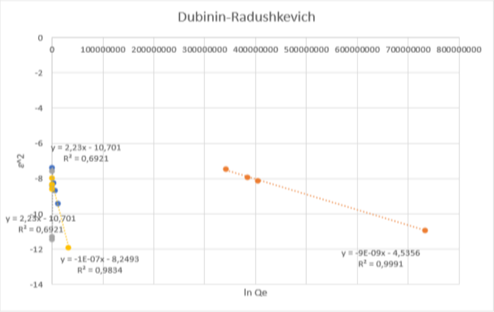

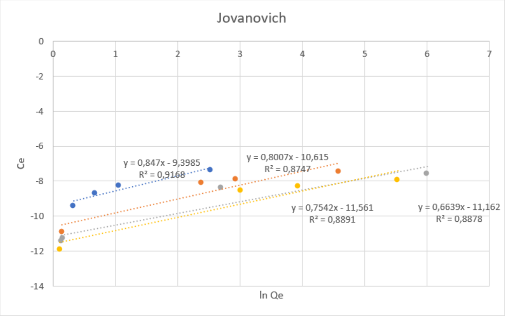

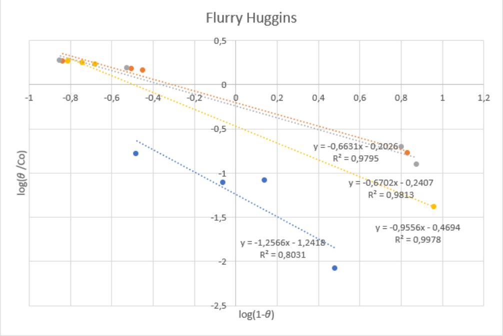

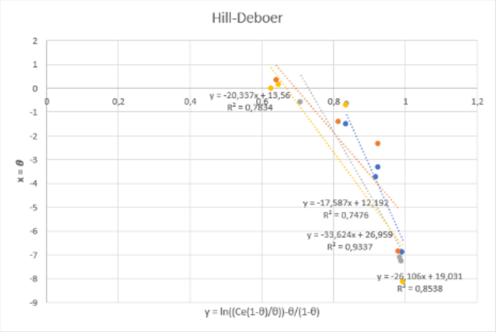

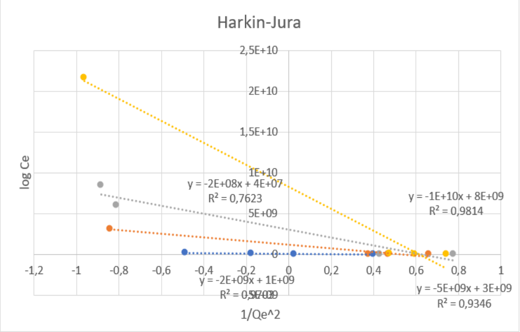

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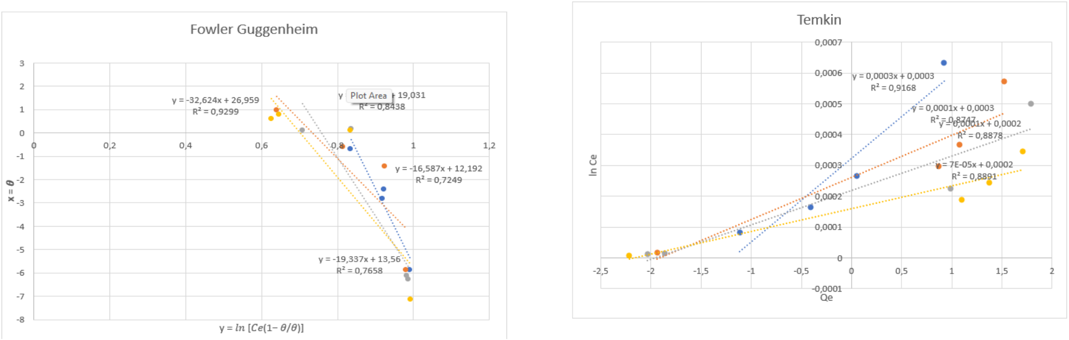

Figure 2. Graph of the effect of zeolite mass variations in the isothermal equation

The results on the general equation model graph of the mass variation of zeolite show that the Langmuir, Freundlich, and Halsey equation models are the most suitable.

Langmuir

The Langmuir equation model describes the monolayer adsorption process. In the process, it can only adsorb one molecule for each molecule of the adsorbent. In the adsorption process, there is no interaction between the adsorbate molecules. This Langmuir isotherm also shows that the maximum adsorbent capacity occurs due to the presence of a single layer (monolayer) of adsorbate on the surface of the adsorbent. Illustration of monolayer formation during adsorption is shown in **Figure 3 (a)**.

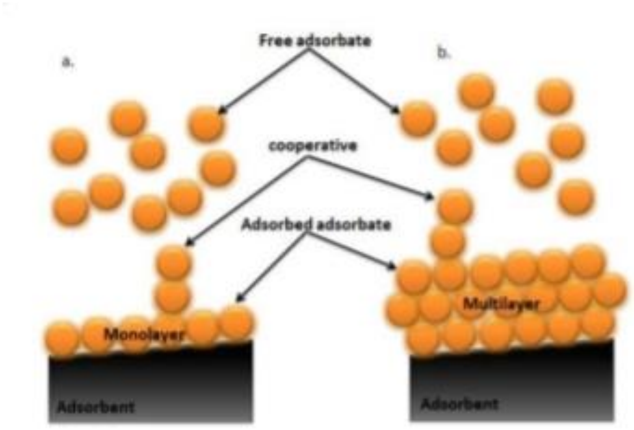

Figure 3. **Illustration of monolayer (a) and multilayer (b) adsorption process** (Maryanti et al., 2017)

The adsorption graph of Langmuir in **Figure 2** can be obtained using **equation (1)**. The parameters of the Langmuir adsorption model used and as the x and y axes are shown in **Table 2.**

Plotting investigations showed that all variations in the mass of the zeolite adsorbent had high junction values ($R^2 = 1$), this indicates that the zeolite mass was 0.2; 0.4; 0.6 and 0.8 grams can be accepted by the Langmuir isotherm model.

Freundlich

Freundlich's isotherm model is represented by **equation (3)**. The Freundlich isotherm method shows that there is a heterogeneous surface, meaning that there are differences in the ability of adsorbs on each active group accompanied by interactions between adsorbate molecules that form a multilayer layer. In this isotherm, it is usually described as physical adsorption because it has a weak bond.

The adsorption graph of Freundlich in **Figure 2** can be obtained using **equation (3)**. The parameters of the Freundlich adsorption model used and as the *x* and *y* axes are shown in **Table 2.**

Plotting investigations showed that all variations in the mass of the zeolite adsorbent had high junction values ($R^2 = 1$), this indicates that the zeolite mass was 0.2; 0.4; 0.6 and 0.8 grams are acceptable by the Freundlich isotherm model.

Halsey

Furthermore, the Halsey isotherm method shows an evaluation of the multilayer adsomso system (Dada et al., 2012). Halsey's model follows **equation (9)**. The adsorption graph of Freundlich in **Figure 2** can be obtained using **equation (9)**. The parameters of the Freundlich adsorption model used and as the *x* and *y* axes are shown in **Table 2.** Plotting investigations showed that all variations in the mass of the zeolite adsorbent had high junction values ($R^2 = 1$), this indicates that the zeolite mass was 0.2; 0.4; 0.6 and 0.8 grams are acceptable by the Freundlich isotherm model.

In the adsorption process the contact time is a determining factor (Reynold, 1982). Where, the amount of adsorbate that is absorbed is one that is influenced by this contact time (Low, Lee and Wong, 1995). According to Jubilate, Zahara, and Syahbanu, (2016), when the contact time is more than 5 hours, it shows that the adsorption absorption greater. This is because the contact time used for the adsorbent to interact with the metal solution is sufficient, where the adsorbate can completely fill the surface. adsorbent.

Meanwhile, when the solution was allowed to stand for ± 8 hours, it was found that the clearest turmeric solution was found in the largest mass of 0.8 grams with the lowest concentration of 6.25 ppm. It showed that the higher the mass of zeolite is used it more clear turmeric solution, or the level of turbidity is increasingly decreased as mass variations, also some concentration dilution as in **figure 4.**

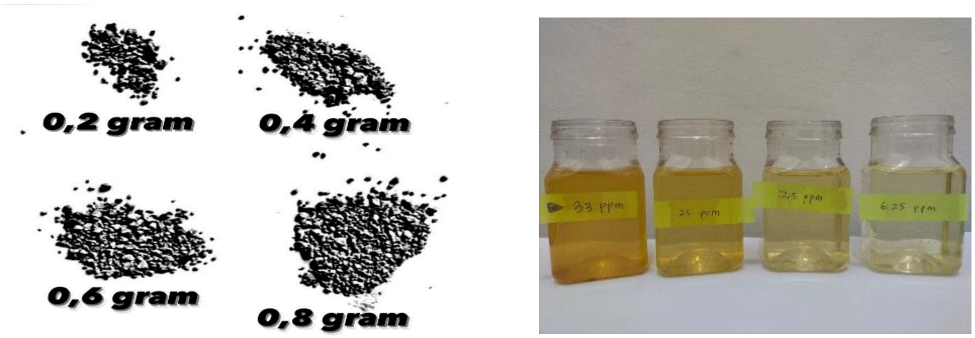

Figure 4. Variation of zeolite mass (a) concentration of diluted Curcumin solution (b)

This is because zeolite has a function as an adsorbent, namely from the nature of the zeolite which is porous and has cations that can be exchanged. The large number of adsorbents is also proportional to the number of particles and the increased surface area of the adsorbent. This also causes the number of sites to bind metal ions to also increase and the removal efficiency also increases (Sumarli, Ian Yulianti, Masturi, Rosyidatul Munawaroh, 2016). Therefore, the amount of dye adsorbed also increases with the number of adsorbents.

CONCLUSION

The results of this study indicate the effect of variations in the mass of zeolite in turmeric solution on the adsorption process as measured by a luxmeter. The experiment was carried out using a batch system method, in which a number of bottles containing a solution (turmeric solution and turmeric solution plus zeolite) were adsorbed. The measurement results were then analyzed and compared with the isotherm equation model. The results showed that the most suitable isotherm model was the Langmuir, Freundlich, and Hasley isotherm model which showed an increase in the level of adsorption and the level of light intensity that increased when the solution was left for ± 8 hours before being measured. This shows that zeolite can absorb dyes, so the water becomes clear. The zeolite mass of 0.8 grams (the heaviest mass) with the lowest concentration of 6.25 ppm showed the highest level of clarity and the highest level of light intensity. Thus, the results of this study indicate that there is an influence of the mass factor and contact time. Where the higher the mass of the zeolite or adsorbent and the more contact time between the adsorbent and the adsorbate, the adsorption and the level of light intensity increase. Meanwhile, when the mass of the adsorbent decreases and the contact time decreases between the adsorbent and the adsorbate, the adsorption rate and light intensity decrease as well.

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