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Utilization of Activated Rice Husk Powder as a Methyl Orange Dye Adsorbent

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Abstract

Inefficient textile waste processing can pollute the environment and endanger the health of the adjacent community. Methyl orange is one of the most extensively used dyes in the textile industry. Various physical, chemical, and biological processes have been utilized to dispose of methyl orange residue. One of the basics is the adsorption method. This research was conducted to determine the adsorption capacity of activated rice husk powder as an adsorbent to reduce methyl orange content. The activation of rice husk powder also influences the decrease in methyl orange concentrations. The variables used are mass, contact time, and pH, and the adsorption isotherm model is determined. The results demonstrated a decrease in methyl orange concentration from the optimal mass variable of 8 grams, contact time of 60 minutes, and pH of 7, with an adsorption capacity of up to 89%. The adsorption isotherm equation is compatible with the Langmuir equation because the R^2 value of 0.926% is closer to 1 than the Freundlich equation.

Keywords: Adsorption, Activation, Adsorption Isotherm, Methyl Orange, Rice Husk Powder.

INTRODUCTION

Indonesia has an enormous population. Regarding that Indonesians from all walks of existence are now enamoured with the newest product trends, it follows that the style of attire is one of the latest trends in fashion that receives a great deal of deliberation. The high interest in manner contributed to the rapid development of the textile industry in Indonesia, which has experienced highly rapid growth each successive year. Textile coloring is one of the negative environmental impacts of the textile industry, despite its many positive contributions to human existence. Inefficient textile waste processing can pollute the environment and endanger the health of the adjacent community.

Methyl orange or methyl orange is one of the most widely utilized dyes in the apparel sector. The formula $C_{14}H_{14}N_3NaO_3S$ is also frequently used in acid-base titrations as an indicator. (Haqiqi, 2018) Methyl orange's carcinogenic and mutagenic properties are detrimental to human health if it contaminates water. Several physical, chemical, and biological processes have been utilized in an effort to manage methyl orange and methyl orange detritus. The adsorption approach is one of the simplest.

The adsorption method occurs when a fluid (liquid or gas) binds to a solid and ultimately forms a film (thin layer) on the stable's surface (Endang Widjajanti, 2011). Utilizing conventional adsorbents incurs relatively higher operational and regeneration expenses.

Numerous conventional adsorbents, such as aluminium, activated carbon, silica gel, and zeolite, are frequently used in adsorption. This adsorbent has effective absorption properties but is not cost-effective (Abdul Halim, 2021).

The capacity of rice husk ash adsorbent to reduce the salt concentration in seawater is diminished. The subsequent step involves optimizing the Titan yellow dye by adsorbing it under varying conditions of time, pH, and temperature to obtain optimal conditions. At the optimal conditions for each adsorbent, specifically rice husk ash adsorbent, optimal acid activation resulted in an adsorption capacity of 832.5 g/g, rice husk ash adsorbent without activation 545 g/g, and activated charcoal of 1150 g/g of titan yellow dye. (Diki Ian Safitri, 2019). Based on additional research findings (Erlan Siswandi, 2022), the use of adsorbents with varying doses of rice husk adsorbent can reduce the concentration of Hg in tailings waste extract solution, with a maximal reduction of 100 percent achieved with 5 grams of adsorbent. Therefore, rice husk has excellent potential as an adsorbent for Hg in tailings waste log extract. Other studies found that the optimal adsorption of Cu and Pb metal ions in wastewater occurred at a mass of 2g of adsorbent and a stirring time of 180 minutes, with an absorption efficiency of 98.63% and 99.39%, respectively, and adsorption capacities of 0.3205 mg/g and 0.1377 mg/g (Abdul Halim, 2010).

Rice husk is an agricultural residue resulting from rice milling activity. Utilizing rice husk as biomass will address the issue of waste disposal and provide an affordable substrate for adsorption. Indonesia expects to produce 54.415.294,22 tons of rice per year in 2021, based on statistics (2019-2021), including 10% rice fiber. Therefore, rice husk residue (biomass) as an adsorbent is plentiful, and rice husk can be utilized as an adsorbent material.

Based on the preceding description, the process of using activated rice husk powder as an adsorbent for methyl orange dye in solution will be carried out. The capacity to employ activated rice husk powder adsorbents needs to be developed. Activation of rice husk powder as an adsorbent for methyl orange requires additional evaluation. Thus, this research has the potential to be employed to identify adsorbents capable of absorbing a substance without the carbonation process instead of by activation.

EXPERIMENTAL SECTION

Materials

Rice husk, methyl orange powder, HCl, and distilled water were used in this study.

Instrumentation

The experiment used UV-Vis spectrophotometry, an oven, a pollinating machine, digital scales, a spatula, a glass beaker, a stir bar, a pipette, an Erlenmeyer, a funnel, filter paper, a measuring flask, a volume pipette, and a ball filler.

Procedure

The research employed contact times of 20, 40, 60, and 80 minutes as independent variables. 4, 6, 8, 10, and 12 grams of sorbent mass. pH 2, 5.7, and 10. The present study applied a concentration of 30 ppm methyl orange in a volume of 100 ml as the fixed variable. Mass, time, and the optimal pH are the constant variables used to determine the isotherm adsorption equation, while the concentration of 15, 30, 45, and 60 ppm methyl orange solutions is variable.

Rice husk was washed with flowing water to remove impurities such as gravel, leaves, and other contaminants. The rice husks were drained and then dried in the oven at 110°C for approximately eight hours. The dried and powdered rice husks were then activated with 1 N HCL solution for 24 hours. The concentration of methyl orange solution used in this study was 30 ppt. The 30 ppm methyl orange solution was prepared by dissolving 30 mg of methyl orange powder in 1000 mL of distilled water in a volumetric flask of a comparable volume. The contact time was optimized by adding 10 grams of rice husk flour to 100 milliliters of 30 ppm methyl orange solution. The total amount of the adsorbent is optimized based on the optimum contact time. During the interim, pH optimization was performed under optimal time and quantity conditions. Using the optimal mass, time, and pH results with a predetermined concentration of methyl orange solution, isotherm adsorption was determined.

RESULTS AND DISCUSSION

Figure 1 depicts the effect of contact duration on the adsorption capacity of activated rice husk powder.

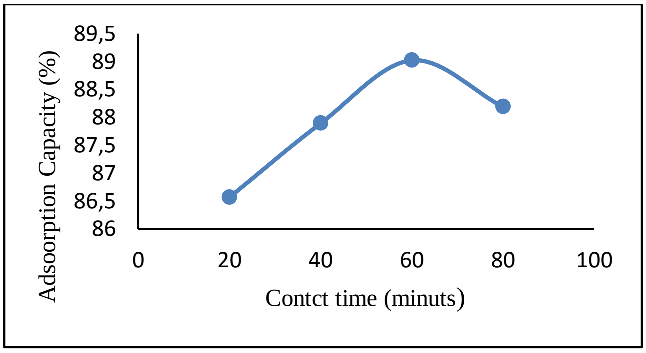

Figure 1: Contact time (minutes) vs. adsorption capacity (%)

The concentration of absorbed methyl orange increases gradually, as depicted in Figure 1. The more extensive the collision between the activated rice husk powder and the methyl orange substance, the greater quantity of methyl orange substance the activated rice husk powder collects. The optimum results for imbibing methyl orange dye with a concentration of 30 ppm and a contact time of 60 minutes were 89.018% and 60 minutes. At contact time variations of 20, 40, and 60 minutes, there was an increase, but at 80 minutes, there was a decline. This occurs because, after the optimal contact time has passed, the adsorbate undergoes a process known as desorption, in which it is released from the surface of the adsorbent. The adsorbent molecules will return to the solution because the surface adsorbent has become saturated (Sringo-ringgo, 2019).

Mass of adsorbents' effect

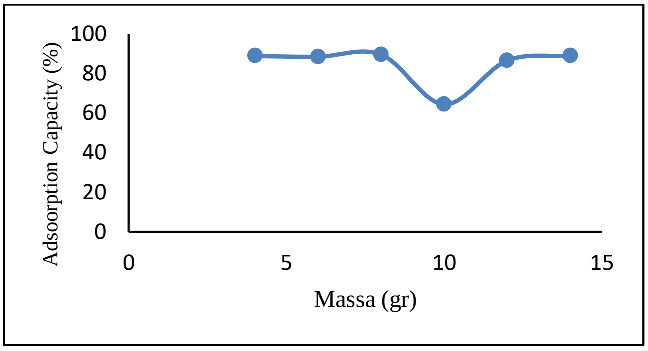

Figure 2. Graph of mass (grams) versus adsorption capacity (%)

Figure 2 illustrates the point. It demonstrates that the concentration of methyl orange adsorbed increases with increasing adsorbent mass. According to (R. Bhaumik, 2011), this can occur due to the addition of adsorbent, specifically the addition of the active side on the surface of the adsorbent, so that the greater the amount of adsorbent, the more methyl orange becomes absorbed. In certain circumstances, however, the absorption percentage will remain constant or even diminish because the adsorbent has reached its saturation point. This is evidenced by the amount of methyl orange absorbed by activated rice husk powder continues to increase between 4 and 8 grams.

At a mass of 8 g, there is an equilibrium between the amount of methyl orange absorbed by the rice husk powder adsorbent and the quantity of methyl orange remaining in the solution, permitting the rice husk powder adsorbent to bind the methyl orange to the maximum amount. Following the adsorption attained its maximum efficiency, the percentage reduction in methyl orange content decreased, to be exact, by 10 grams. The decline is caused by the insufficient concentration of methyl orange in the solution to cover all the active sides of the adsorbent and the existence of clumping, which decreases the effective surface area over the absorption of methyl orange substances. (Siringo-ringgo, 2019)

The Effect of pH

Figure 3 demonstrates the effect of pH on the adsorption capacity of methyl orange dye by rice husk powder adsorbents

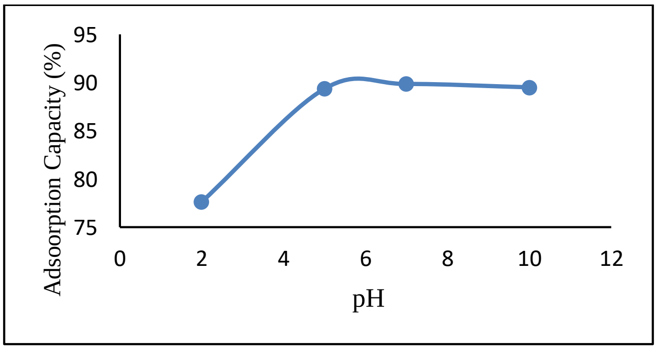

Figure 3. Correlation between the pH and adsorption capacity (%)

Maximum methyl orange adsorption by rice husk adsorbents appears at pH 7 with an adsorption percentage of 89.85 percent, as shown in Figure 3. With an extended period and optimal adsorption mass of 8 grams of rice husk powder and 60 minutes. Based on data indicating variations in the pH of the adsorption system at all levels. An increase in pH indicates a decrease in H+ ions in a system. This suggests that in the adsorption process, there is the binding of H+ from the surface and staining; by binding to surface H+ ions, the possibility of releasing H+ ions into the system is low; this is consistent with observations indicating that the pH of the system rises (Endang Widjajanti, 2011).

Isoterm Adsorption

By transforming the Langmuir and Freundlich isotherm equations into a straight-line equilibrium curve, the adsorption isotherm by the material that absorbs can be determined. The determination of the equilibrium model is contingent on the value of a determinant coefficient (R^2) close to one. Figures 4 and 5 depict adsorption isotherms.

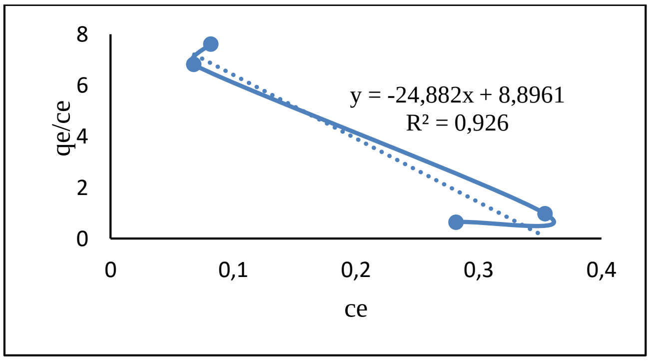

Figure 4. Isotherm Langmuir

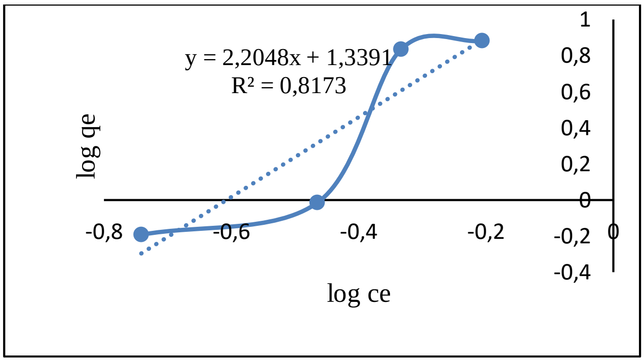

Figure 5. Isotherm Freundlich

The determination of the isotherm reveals the distribution of the Methyl Orange solution on the adsorbent over the equilibrium adsorption process by exposing the mass of the adsorbent per gram. In this study, the correct isotherm is identified based on the value of the determinant coefficient (R^2), which fits if it attains a value close to one, which is optimum.

Table 1. The determination of the adsorption constant using the Langmuir and Freundlich isotherm equations.

Isotherm Langmuir	**Persamaan Garis**	**Ka**	**Qm**	**R^2**
	y = -24,882x + 8,8960	24,882	0,35753	0,926
Isotherm Freundlich	**Persamaan Garis**	**Kf**	**n**	**R2**
	y = 2,2048x + 1,3391	21,834	0,45356	0,8173

The R2 value for the isotherm pattern of the Langmuir equation is 0.926, closer to 1 than the R2 value for the Freundlich equation, which is 0.8173. This Langmuir adsorption isotherm is based on the premise that monolayer adsorption that occurs on the surface of the adsorbent under conditions at the active sites is homogeneous (Atkins, 1999). A robust covalent bond exists between the adsorbate and the adsorbent, allowing the Langmuir isotherm to occur chemically. At the same time, Freundlich is a physical adsorption process that involves the formation of a multilayer layer. The greater the values of Kf and n, the greater the adsorption intensity (Permatasari, 2021). The 1/n value on the Freundlich isotherm is a heterogeneous factor that indicates the adsorbent's adsorption intensity. To measure the interaction strength between the adsorbent and adsorbate. The 1/n value falls between 0 and 1, indicating that the adsorption process is appropriate for heterogeneous adsorption processes. The adsorbent is homogeneous for the adsorption of rice husk powder with methyl orange (Siringo-ringgo, 2019).

CONCLUSION

According to the research results, mass, contact time, and pH can influence the adsorption process in a solution. The optimum outcomes from the variable contact time of rice husk powder and methyl orange adsorbent were 60 minutes with an adsorption yield of 89.01%; from the variable mass of the adsorbent and methyl orange powder was 8 grams with an adsorption yield of 89.5%; and from the variable pH of the powder adsorbent rice husk and methyl orange was pH 7 with an adsorption yield of 89.85%. The R2 value for the Langmuir equation applied to the rice husk powder and orange meta adsorption isotherm model is 0.926%. The Langmuir type is chemical adsorption in a robust covalent bond between the adsorbent and the adsorbate.

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