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Adsorption Of Methylene Blue Dye Using Silica Adsorbent Extracted From South Coastal Napa Soil

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Abstract— Methylene Blue is one of the dyes that is widely used in industries such as the textile industry, printing industry and paint industry. One way to manage methylene blue waste is by adsorption method which adsorption itself is simpler and environmentally friendly. Silica is known to be used as an adsorbent for the absorption of methylene blue dye which is better than activated carbon and zeolite. The purpose of this research is to determine the absorption capacity of silica extracted from napa soil against methylene blue dye. This research uses a batch method with concentration variation (50, 100, 150, 200, 250, 300) ppm, pH variation (2, 3, 4, 5, 6) and contact time (10, 20, 30, 40, 50, 60) minutes. The results of this study obtained optimum conditions in each variation at a concentration of 250, pH 5 and contact time of 40 minutes. Obtained a capacity of 18.84858 with a percentage of uptake of 99.72%.

Keywords—Adsorption; Methylene Blue; Silica.

I. Introduction

Contamination of water resources is a highly debated issue on an international scale, as it has long-term or even lethal consequences for living things (Hamad & Idrus, 2022). Water pollution was first caused by the textile industry, followed by the printing industry, as well as paper, paint and leather production companies These industries consume most of the dyes and produce dye-laden effluents that are eventually released directly into the environment, thus posing a significant environmental problem due to the toxic and objectionable nature of the dyes (Katheresan et al., 2018).

Methylene blue (MB) is a synthetic dye that is widely used as a colorant for paper, wool, silk, and cotton. However, the release of partially or untreated MB dye-containing wastewater from any of the above-mentioned industries can cause many health risks(Oladoye et al., 2022). Among the various dye removal techniques currently available in literature, adsorption is a cheap operation compared to others as well as superior in terms of initial cost, design flexibility and simplicity, ease of operation and insensitivity to pollutant toxicity (Meili et al., 2019)(De Oliveira et al., 2011).

Recently, mesoporous silica materials have been widely used for the treatment of contamination in water, such as heavy metal ions, dyes, phenolic compounds, pesticides, etc., which is due to their large specific surface area, high pore volume, excellent stability, low toxicity and transparency (Yuan et al., 2019). Silica can be obtained through synthesis or extraction from biological and non-biological materials. Silica from biological natural materials can be obtained from husk ash, palm pulp and bagasse. While for non-biological natural materials can be obtained from coal fly ash (Ishmah et al., 2020). Therefore, silica extraction using natural materials such as napa soil can be utilized as a valuable inorganic material (Mawardi et al., 2018)(Todkar et al., 2016).

Silica has several active groups that are thought to play a role in the adsorption process such as silanol (≡Si-OH) and siloxane (≡Si-O-Si≡). Therefore, in this study to determine the ability of silica to adsorb methylene blue dye by batch method.

II. Research Methods

Silica extraction begins with the preparation of napa soil calcined at 750OC for 4 hours (Mawardi et al., 2022). The napa soil sample was weighed as much as 100 grams and dissolved in 1M HCL solution for 12 hours, then the filtered residue was rinsed and dried in an oven at 110OC (Ishmah et al., 2020). Then the napa soil sample was diluted with NaOH with a concentration of 8M in a ratio of (1: 5) accompanied by heating at 95OC for 2 hours with a 600 rpm magnetic stirrer and then filtered and obtained Na-Silicate. After that, 6M HCL solution was added to form silica and calcined at 550^{O}C for 2 hours (Munasir et al., 2015).

Adsorption was carried out by weighing 0.2 grams of synthesized silica to absorb Methylene Blue with a volume of 20 mL and carried out with a shaker. In this batch method, several factors affect absorption, namely the effect of concentration (50, 100, 150, 200, 250, 300) ppm, pH (2,3,4,5,6) and contact time (10, 20, 30, 40, 50, 60) minutes. The absorption capacity obtained from each treatment was measured using a UV-Visible Spectrophotometer and calculated using the C0-C1 equation.

III. Results and Discussion

A. Concentration Effect

In this adsorption process using silica 0.2 grams and a volume of methylene blue 20 mL which varies 50, 100, 150, 200, 250 and 300 mg/L. This variation is done with a predetermined volume and mass. In theory, the higher the concentration used is, the absorption of silica will also increase until it reaches a saturation point and is no longer able to absorb. The concentration of methylene blue solution can affect the absorption, until silica is unable to absorb methylene blue solution.

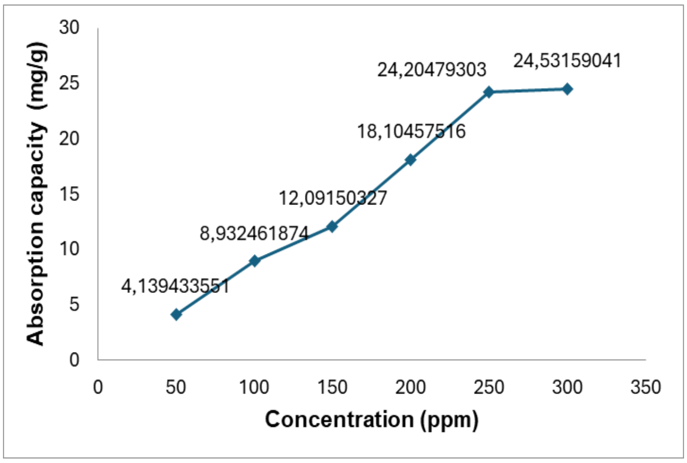

Fig 1. Effect of solution concentration on methylene blue absorption using silica from napa soil

The figure above shows that the absorption capacity of methylene blue dye increases according to the concentration level of methylene blue used. The optimum absorption capacity occurs at a concentration of 250 mg/L with an absorption capacity of 24,20479303 mg/g and an absorption percentage of 95.1606%. Where, there is an equilibrium between methylene blue ions and silica adsorbent active sites, this indicates that methylene blue ions have bound to all active sites of silica adsorbent.(Wong et al., 2019) It can be explained that the number of adsorbed ions is proportional to the number of active sides available on the adsorbent.

When the initial concentration of methylene blue was increased from 50 mg/L to 200 mg/L, the absorption capacity also increased. The increase in absorption capacity is due to methylene blue ions that bind to the active site of the silica adsorbent increasing until the active site is saturated. When the active side of the adsorbent is saturated, then at a concentration of 300 mg/L the absorption capacity will decrease (Hevira et al., 2020)

B. Ph Effect

Variation of adsorbate pH was conducted to see the effect of pH on methylene blue absorption using silica adsorbent extracted from South Pesisir napa soil. In this study, pH variations were carried out starting from pH starting from pH 2, 3, 4, 5 and 6 with a concentration of 250 ppm methylene blue solution and a contact time of 60 minutes. The following is a graph of the absorption capacity of silica against methylene blue with the influence of pH.

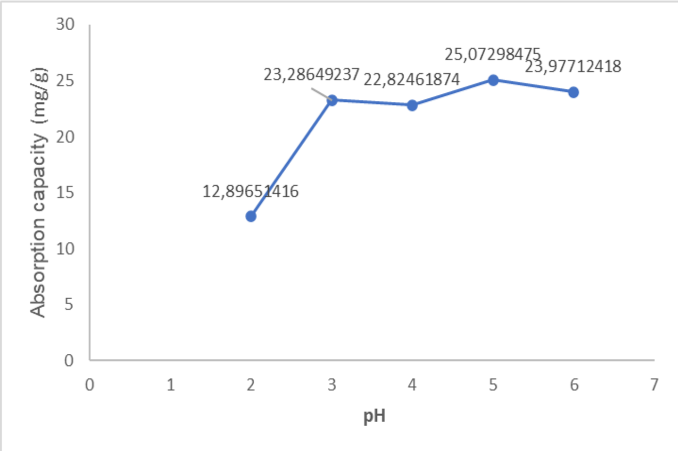

Fig 2. Effect of pH on adsorption

The figure above shows that the adsorption of methylene blue using silica adsorbent extracted from south coastal napa soil can occur optimally at pH 5 with an absorption capacity of 25.07298 mg/g with an absorption percentage of 98.9127%. Then at pH 2 the absorption capacity was 12.89651 mg/g with a percentage of absorption of 79.72391%. While at pH 6 there was a decrease in absorption capacity of 23.97712 mg/g.

At low pH (acidic) methylene blue ions can enter the adsorbent pore structure, while at high pH (alkaline or tends to neutral) the zwitter ion form of methylene blue increases aggregation to form larger molecules (dimers) so that it is more to enter the adsorbent pore. This is due to too many OH- ions in the solution are not able to be captured by the dye so that there are still many free OH- ions in the solution which causes competition between the dye and free OH- in the solution which causes competition between the dye and free OH- to occupy the silica surface which will reduce the adsorption power of the dye.

IV. CONCLUSION

From the research that has been done, it can be concluded that silica extracted from napa soil from the south coast can optimally adsorb methylene blue dyes using the batch method with optimum absorption conditions at pH 5 and a concentration of methylene blue solution of 250 ppm.

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