|| Volume 8|| Issue 1 || January 2024|| ISSN (Online) 2456-0774
INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH
AND ENGINEERING TRENDS

Removal of Methylene Blue Dye by Adsorption using Sand Recovered From Demolished Waste.

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Abstract: This study investigates the potential of utilizing sand obtained from demolished waste as an adsorbent for the removal of Methylene Blue dye from aqueous solutions. With a growing concern for environmental pollution caused by dye contaminants, the need for cost-effective and sustainable solutions is paramount. In this research, response surface methodology (RSM) has been used for optimising a variety of water and waste water treatment processes. RSM is a collection of mathematical and statistical techniques for evaluating the effects of several variables, and obtaining the values of process variables that produce desirable values of the response. Sand reclaimed from construction and demolition waste is examined for its adsorption capacity. The experimental procedure includes batch adsorption studies under various conditions, such as contact time, initial dye concentration. The results demonstrate that the reclaimed sand possesses promising adsorption properties, with significant dye removal efficiency. The results showed that Demolishe sand was effective in removing MB, with a maximum removal capacity of 93.97% , initial MB concentration of 100 mg/L, and contact time of 40min. Equilibrium data are analyzed using isotherm models, and kinetic studies shed light on the adsorption mechanism. This study provides valuable insights into the potential application of waste-derived sand as an eco-friendly adsorbent for the removal of dye contaminants, contributing to both environmental remediation and resource recycling efforts.

Keywords: *RSM, Utilizing Sand, Blue Dye*

I.INTRODUCTION:

The textile industry generates large quantities of dyes during various processes and generates complex products. Many industrial processes use different synthetic chemical dyes for various purposes. It is estimated that 10–15% of the dye is lost during the dyeing process and released with the wastewater. Dyes are applied to the substrates to give them permanent colour, which can resist fading upon exposure to water, light, oxidizing agents, sweat, and microbial attack. Due to these advantages, various dyes are used in different industries such as textiles, food, rubber, printing, cosmetics, medicine, plastic, concrete, and the paper industry for multiple purposes.These industries generate a tremendous amount of wastewater containing carcinogenic and toxic dyes that pollute water, which becomes unfit for human consumption. Among these industries, the textile industry is the most dye-consuming industry utilizing textile dyes, which are highly complex compounds with different structural groups. One of the highest-consuming materials in the dye industry is methylene blue (MB), which is commonly used for colouring silk, wool, cotton, and paper.

One of the adsorbents is demolished sand due to its high adsorptive properties. However, demolished sand is easily and economically available. Many studies have been conducted to find out inexpensive alternative adsorbent. That's what inspired us to use Demolished sand as adsorbent since the latter has a very low commercial value.

Adsorption is a major industrial separation technique for the purification of effluent media. It is a mass transfer operation through which a solid material can selectively remove dissolved components from an aqueous solution by attracting the dissolved solute to its surface. Therefore, it involves the interphase accumulation of concentration of substances at a surface or at the inter phase.

Since adsorption process is the most economical method doesn't require high energy consumption and has a simpler operational capability and is a unit operation, easily feasible technically.

II.LITERATURE SURVEY

Saeed B. Bukallah et al 2006 studied The removal of Methylene Blue (MB) dye from aqueous solution present as a pollutant material in textile waste water was studied at 298 K in terms of its adsorption behaviour. Local sand sample was used as an adsorbent in this work. The textural properties of the sand including surface area, mean pore radius and total pore volume were examined from the low-temperature adsorption of nitrogen at 77 K. The conditions for maximum adsorption of the dye on sand were optimized. It was seen that under optimized conditions, up to 92% dye could be removed from solution onto the sand surface. The adsorption data were fitted to Freundlich and DubinineRaduushkevich equations for the calculation of various adsorption parameters. The Freundlich constants n and A were determined as 0.9682 and 0.639 mol/g, respectively. The sorption energy calculated by the DubinineRaduushkevich equation was found to be 1.22 kJ/mol. The adsorption behaviour of the dye was also investigated in terms of added cations and anions. It was found that the dye adsorption decreased considerably in the presence of thiosulphate, potassium, nickel and zinc ions.

Dr. L.Nageswara Rao et al 2013, studied Removal of dyestuffs from wastewater occurs by either biological methods or physiochemical methods (e.g., adsorption, oxidation-reduction, chemical coagulation, ozone treatment, and membrane

filtration). Low cost adsorbents have gained attention over decades as a means of achieving very high removal efficiency to meet discharge standards. The saw dust is a potentially useful material for the removal of dyes from industrial wastewater. It is suggested that the work is designed to increase the scale of saw dust application to cope with the removal of methylene blue component under industrial conditions should be initiated. The saw dust has a substantially larger capacity to remove the reactive dye by Adsorption than all of the other components. The performance analysis was carried out as function of various operating parameters such as contact time, initial concentration of dye, adsorbent dose, particle size and pH. Performance studies revealed that a very high percentage removal of color was achievable. The study had shown that for sawdust the percentage of dye removal was high. The Adsorption data for the uptake of methylene blue verses contact time at initial concentration 0.02 g/L was shown. It indicated that the Adsorption of methylene blue increases with increase in contact time. The amount of dye uptake was found to occur in the first rapid phase (25 minutes) and their after the sorption rate was found to be constant. This is due to an increased number of vacant sites available at the initial stage and after a lapse of time, the remaining vacant surface sites are difficult to be occupied due to repulsive forces between the solute molecules on the solid and bulk phases. The study has shown that for Saw Dust the percentage of dye removal was 70% high at initial concentration 20 ppm at a shaking speed of 160 rpm. The lowest dye removal 54.6% was observed for concentration of 100 ppm. This indicates that an increase in the dye concentration had caused the decrease in the percentage of dye removal, even though the amount of dye being adsorbed is increased. This is due to increase in the driving force of the concentration gradient as an increase in the initial dye concentration and decrease in percentage Adsorption may be attributed to a lack of sufficient surface area to accommodate much more adsorbate available in the solution.

Mohammed M.A. et al 2013 studied adsorption process has been found to be one of the best treatment methods for Methylene blue (MB) removals. As the control of water pollution has become an increasing importance in recent years, the use of physical/chemical treatments such as membrane filtration, reverse osmosis, coagulation/flocculation and fenton reagents are not economically feasible. The use of different biosorbent as an alternative low cost adsorbent in the removal of methylene blue has been extensively studied and compiled, together with their adsorption capacities and experimental conditions such as adsorbent dose, pH of the solution, temperature and equilibrium time. But, there are issues as regards to draw back in the use of activated sorbents which were also discussed briefly. However, it is evident from the results of experiments in the literatures surveyed that various low-cost adsorbents have shown good potential for MB. Based on the literature reviewed so far, it is evident that, recently, there has been an increase in production and utilization of dyes, resulting in an increase in environmental pollution. Various techniques have been utilized in the removal of dyes. However, practically a successful methodology for removal of all types of dyes at low cost has not been established.

Ahmed El Yacoubi1 et al 2013 studied Synthetic dyes are widely used in industries such as rubber, textiles, plastics, paper, and cosmetics to color their products. The effectiveness of adsorption for dye removal from wastewater has made it an ideal alternative to other expensive treatment methods. The purpose of this study was to investigate the feasibility of optimization and removal of dye Methylene Blue (MB) from aqueous solutions by using beach sand as an extremely low cost adsorbent. The sand was collected from south of Morocco. The adsorption of Methylene blue on sand has found to be dependent of contact time. Under the optimum conditions: A pH = 6.5 and T = 20°C, the sorbent could remove more than 99%. According to the results of experiments in this research, adsorption kinetic was found to adopt the pseudo- second order kinetic model, which was the best appropriate model to describe the adsorption process. The maximum adsorption capacity was found to be 0.25mg.g-1 and a kinetic constant K2 of 1.99 g.mg-1min-1. This makes it an interesting option for dye removal from aqueous solution of dye. This work consisted on studying the adsorption of Methylene Blue which is used as a dye by using beach sand as adsorbent. The contact time was investigated. The adsorbed amounts of dye increased with increase in contact time and reached the equilibrium in 30 mins. The equilibrium data have been analyzed using the first pseudo order and the second pseudo order models. The characteristic parameters for each model and related correlation coefficients have been determined from graphs of their linear equations. It was found that the second pseudo order model appears to fit the isotherm data better than the first pseudo order model. It can be concluded that the adsorbent used in this study has the capacity of removing the MB from dye wastewater.

III.METHODOLOGY

Weighing balance

A weighing balance, also known as a balance scale, is a precision instrument used to measure the mass or weight of an object. It consists of a horizontal beam or lever that is supported at its center, with two pans or trays suspended from each end. Weighing balances come in various types, including mechanical balances that use a system of levers and counterweights, and electronic balances that provide digital readouts. They are used in a wide range of applications, from laboratories for precise measurements to commercial and industrial settings for bulk weighing. Hence, any errors in the measurement can significantly affect the accuracy of the results. Therefore, it is necessary to take outmost care in using the weighing balance during the experiment.

3.2 Glassware and plastic containers

A machine shaker was used for all the adsorption experiments. A UV-ray spectro- photometer was used to determine the

absorbance. Glass wares & conical flask were used to handle the solutions. A meter balance was used to weigh the samples. Some of the essential glassware includes beakers, measuring cylinders, pipettes, burettes, and volumetric flasks.

3.3 Flocculator

A flocculator is a device used in water treatment processes to promote the agglomeration of suspended particles in water, forming larger flocs that can be more easily removed. It typically consists of a series of mixing chambers or paddles to encourage particle collision and bonding, aiding in the clarification and purification of water. Flocculation is an important step in the treatment of drinking water and wastewater. In the case of the above project, a flocculator can be used to mix the coagulant and flocculant chemicals with the methylene blue solution to promote the formation of larger flocs that can be more easily removed from the solution. The flocculator can also be used to mix the solution during the filtration process to aid in the removal of the flocs.

The flocculator typically consists of a series of mixing chambers or tanks that are equipped with mixing paddles or blades. The paddles or blades are driven by a motor and rotate at a constant speed to provide uniform mixing. The design of the flocculator can vary depending on the specific application and the volume of liquid being treated.

Spectrophotometer

A spectrophotometer is a sophisticated analytical instrument used to measure the intensity of light at various wavelengths, typically in the ultraviolet (UV) and visible (VIS) regions of the electromagnetic spectrum. It is widely used in chemistry, biology, physics, and various scientific fields for quantitative analysis, especially in areas such as chemical analysis, molecular biology, and environmental monitoring.

Spectrophotometers are essential tools for researchers and professionals, providing precise and quantitative data for a wide array of scientific and industrial purposes. They are valued for their ability to accurately measure the absorption or transmission of light by substances, helping researchers and analysts make informed decisions based on the obtained data.

Choosing a specific wavelength for a measurement depends on the properties of the sample being analysed and the goals of the experiment. For example, in some cases, certain molecules or substances may have a higher or lower absorbance at specific wavelengths, making those wavelengths more suitable for measurement.

In the case of using 663nm as the wavelength in a spectrophotometer, it's likely that the experiment is designed to measure the absorbance or transmission of light by a sample at that specific wavelength. This wavelength is in the red part of the visible spectrum and may be chosen because it is absorbed by certain compounds, or it may be used as a reference wavelength in a two- wavelength measurement to correct for background absorbance.

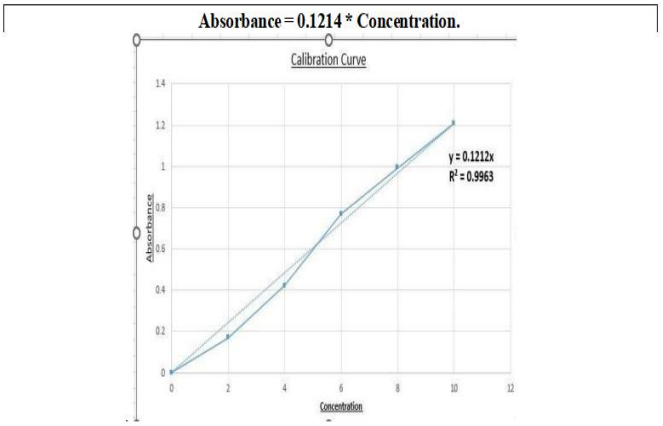
IV.EXPERIMENTAL RESULTS

The calibration curve is an essential tool for determining the relationship between the concentration of the methylene blue solution and its absorbance. In order to prepare the calibration curve, a series of standard solutions with known concentrations 20 ppm were prepared. The wavelength of 663 nm was used for measuring the absorbance of these standard solutions using a UV-Visible spectrophotometer.

Concentrations	Abs
0	0
2	0.168
4	0.421
6	0.768
8	0.994
10	1.208

Table 5.1 Absorbance at different concentration

The values of absorbance were plotted against the corresponding concentrations, and a linear regression analysis was performed on the resulting plot to obtain an equation that relates the absorbance and the concentration of methylene blue. The equation was found to be.



The calibration curve is important because it provides a way to quantify the amount of methylene blue present in the solution. By measuring the absorbance of the sample and using the calibration curve equation, the concentration of methylene blue can be determined accurately. This helps in assessing the adsorption capacity of the demolished sand material and optimizing the dosage and contact time for maximum removal of methylene blue.

RSM Analysis

The results of preliminary experiment were given as an input to RSM, to which it generated 13 responses. These 13 combinations were performed individually to which following results are generated. (Refer Table.1).

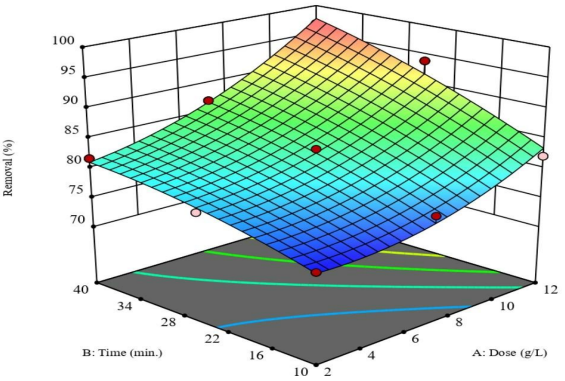
The RSM model generated a series of combinations of adsorbent dose and contact time, which were then tested and the results were analyzed. The adsorbent dose was varied from 2g, 4g, and 12g, while the contact time was varied from 10min, 20min, and 40min.

The obtained results were analysed using statistical software and a response surface plot was generated. This plot provided a visual representation of the relationship between the adsorbent dose, contact time, and the response (adsorption efficiency). The plot showed that there was an optimal combination of dose and contact time that resulted in maximum adsorption efficiency.

Further, these results were given as an input to RSM to get an optimum dosage and contact time. RSM generated 26 combinations of dosage and contact time for maximum removal. Out of these 26 responses, this choose 3 combinations which were; optimum combination according to RSM, the one with least contact time and lastly the one with least dosage respectively. The following results were observed from the above mentioned.

The obtained results were analysed using statistical software and a response surface plot was generated. This plot provided a visual representation of the relationship between the adsorbent dose, contact time, and the response (adsorption efficiency). The plot showed that there was an optimal combination of dose and contact time that resulted in maximum adsorption efficiency.

Std	Run	Factor 1 A: Adsorbent Dose (mg/)l	Factor 2 B: Contact Time min.	Response 1 Removal %
0	0	0	0	0
4	1	12	40	93.96
5	2	2	25	82.01
13	3	7	25	86.13
1	4	2	10	78.71
6	5	12	25	89.61
9	6	7	25	86.71
8	7	7	40	87.04
12	8	7	25	86.46
11	9	7	25	85.89
10	10	7	25	85.72
7	11	7	10	87.54
2	12	12	10	96.78
3	13	2	40	81.76



V.CONCLUSION

In conclusion, the present study demonstrated that demolished sand sample can be utilized as an efficient and effective adsorbent for the removal of methylene blue from aqueous solutions. The results showed that the demolished sand have excellent adsorption capacity for methylene blue. The maximum removal was achieved at a dosage of 12gm for 100 ppm solution of methylene blue for the contact time of 40 minutes.

From the contact time studies, it was seen that % removal of blue methylene for 1st 10 minute increases but for next 10 minutes, the slope gets further increase & thereafter slope gets decrease for next 40 min & finally attains a steady value after a very long time This trend can be attributed .to the fact that as the contact time increases more is the adsorbate-adsorbent interaction & thus leads to more adsorption & hence % removal of MB also gets raised with respect to increase in contact time.

For adsorbent dosage, it was seen that % removal of methylene blue increases with increase in adsorbent dosage. This trend can be attributed because of more dosage, the surface area exposed to dye solutions gets more so that more dye can be adsorbed into the pores of the adsorbent hence more is the % removal of MB. For methylene blue dosage, the % removal of MB start

decreasing with respect to increase in concentration of MB. This happens due to fixed amount of adsorbent in increasing Methylene blue concentration.

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