REMOVAL EFFICIENCY OF METHYLENE BLUE DYE USING CHEMICALLY ACTIVATED WATERMELON RINDS AS A LOW-COST ADSORBENT

Chaitra G D[1], Sumana Y B[2], Praveen Kumar G B

[1]PG Scholar, Department of Civil Engineering, Bapuji Institute of Engineering and Technology, Davanagere-577004, Karnataka, India.
[2]Assistant Professor, Department of Civil Engineering, Bapuji Institute of Engineering and Technology, Davanagere-577004, Karnataka, India.
[2]Assistant Professor, Department of Civil Engineering, Bapuji Institute of Engineering and Technology, Davanagere-577004, Karnataka, India.

---***---

Abstract - *Activated carbons are extensively used as efficient and versatile adsorbents for purification of water, air and many chemical and natural products. Watermelon Rind is used as an adsorbent for this research work. This is an abundant agro waste product available in all season. Methylene blue is a commonly used cationic dye for colouring, this can cause eye burns in humans and animals, causes methemoglobinemia, cyanosis, irritation to the skin and if indigested can leads to irritation in gastrointestinal tract, nausea, vomiting. According to batch studies it was concluded that adsorption depend on contact time, adsorbate concentration, pH and also adsorbent dosage. The results show maximum dye removal efficiency of 95 -99.659% adsorption for Sulphuric acid treated with Activated watermelon rind. When adsorbate concentration increases accordingly activated carbon adsorbent dosage gets increased. Contact time of 180minutes and pH of 9 was considered as optimum in the present study.*

Key Words: **Watermelon Rind, Methylene Blue, Adsorbent, Activated carbon, pH, Contact time.**

1. INTRODUCTION

Wastewater which is discharged from industries contain various kind of contaminants. In that dyes are the major contaminants that are being discharged from industries. Many industries like textile, paper and pulp, cosmetics, pharmaceuticals, food and painting industries release wastewater associated with dyes. Because of its complex composition, high concentration, highly stable and poor biodegradable properties, those dyes are very difficult to remove from the wastewater which is released by different types of industries. In industries like textile, water is used in large quantity which also results in large amount of wastewater that contain dyes. The concentration of dye is very high such that even a less amount of dye which is present in water is detectable and it is not acceptable. Major problem associated with dyes is that these are aesthetically visible in quick succession and reduces the light penetration coming from the sun into the water body causes several health effects such as skin irritation, allergy and any prolonged consumption can make these dyes carcinogenic and mutagenic. There are many methods used to abate different dyes from the wastewater.

Activated carbon method considered as the most effective adsorption method. This method is widely preferred because of its high performance and cost effectiveness. Extra pores present in the activated carbon has made it more effective in adsorbing the dyes compared to the normal adsorbents. Many low cost adsorbents are available and proved to be efficient to adsorb the dyes and one such adsorbent is Watermelon Rind.

1.1 Objectives of the study:

1) To prepare Watermelon rind activated carbon.
2) To investigate Methylene Blue dye removal efficiency using batch method along with efficiency of colour removal.
3) To evaluate the potential of naturally available adsorbents in adsorption of Methylene Blue dye.
4) To determine the amount of dye adsorbed by activated watermelon shell powder by varying the pH, contact time and dosage of adsorbent.

2. MATERIALS

2.1 WATERMELON RIND:

Watermelon Rind is the hard protective layer of the Watermelon fruit. Watermelon fruit is widely used all over the world mainly China is the biggest producer. The peel which is separated from the fruit is considered as the waste material. The study is done to make use of waste rind in order to abate Methylene Blue dye by the process of adsorption.

Fig. 2.1: Dried & Grounded Watermelon Rinds

2.2 METHYLENE BLUE:

Methylene Blue is categorised as a cationic dye. It had the chemical formula $C_{16}H_{18}N_3SCl$, weighed 319.85g/mol, and had a 665nm absorption wavelength. It was heterocyclic aromatic compound. Heinrich Caro, a German Scientist, analysed methylene blue for the first time in 1876. It was a solid, odourless, dark green powder at room temperature, and it will turn blue when combined with water. Methylene blue dye is widely used for various dyeing processes in the textile, paper, and leather industries.

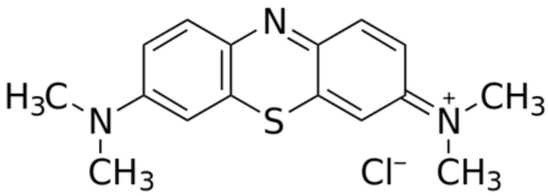

Fig. 2.2: Methylene Blue structure

2.3 PREPARATION OF ADSORBENT:

The collected watermelon rinds were washed with distilled water and separated from endocarp of fruit to take off all the dirt and other impurities. Later it is sliced to a size of 1 mm for easy drying purpose and it is exposed to sunlight for about 5 days during the peak temperature. After that, the dried pieces are ground into powder form and stored in air tight container for future use. The powdered rinds were soaked in concentrated H_2SO_4 solution for 24 hours as Weight: Volume ratio. Later the adsorbent was washed several times with distilled water to take off all the acid content present in it till it gets the pH of 6. Then the adsorbent was sundried till all the moisture gets evaporated. Later it was kept in hot air oven at 230^0C for 3 hours. The adsorbent is used throughout the experiment.

Fig. 2.3 Chemical activation of watermelon rind

2.4 ADSORBATE PREPARATION:

About 1.0g of Methylene blue was taken and dissolved in 1 litre water which produced a Methylene blue of concentration 1000PPM. From 1000PPM solution 100PPM, 80PPM, 60PPM, 40PPM and 20PPM solutions were prepared.

Dilution for stock solution is calculated by using

$(C_1 \times V_1)_{\text{Stock}} = (C_2 \times V_2)_{\text{Dilution}}$ formula for different concentration.

The chemicals used for this study were of analytical-grade reagents. For preparing all of the solutions and reagents double-distilled water was used (0.1M HCl or 0.1M NaOH was used for initial pH).

3. METHODOLOGY:

3.1 RESPONSE SURFACE METHODOLOGY:

In Minitab, RSM is a strong statistical tool for optimization. It is a mathematical methodology helpful for creating an optimization process and has an advantage over other approaches typically utilized in the case of numerous variables. When compared to a central composite design, the Box-Behnken method of experiment design offers the greatest efficiency for a response surface methodology that primarily depends on three factors: pH, initial concentration, adsorbent dosage, and occasionally temperature and contact time. It also predicts the number of trails by knowing the three levels (low, medium, and high), and the number of runs is lower. The Box-Behnken method is primarily used in a variety of fields, including capillary electrophoresis, spectro metric methods, chromatographic method optimization, and electroanalytical method and so on.

3.2 ADSORPTION STUDY:

Adsorption research was conducted in accordance with the runs provided by BBD. In accordance with the experiment's design, a stock solution of the Adsorbate Methylene Blue dye was created. (100 ml) of the ready stock was transferred to a 250 ml conical flask. According to the plan, watermelon rind activated carbon was applied, and cling foil sheets was placed on top. The mixture was maintained in a shaker for a constant 2 hours at a temperature of 27^0 C and 130 rpm. Then it was filtered and put through a spectrophotometer test at a wavelength of 664 nm. Variations in the samples, optical densities and concentrations were documented, and the same five trails were run.

Batch studies were conducted to determine the effects of the adsorbent by changing the dosage of activated watermelon rind from 0.5g to 2.5g at equal concentrations by constant time and pH, as well as the effects of contact time by changing the contact time from 30min to 300min by constant adsorbent dosage and pH. Additionally, the effects of pH variation were investigated by changing the pH from 2 to 10 by constant time and adsorbent by varying the pH by adding 0.1 M HCl. By varying its concentration while keeping the other ingredients constant, the effect of the adsorbate was also investigated. Further testing was done using the Box-Behnken design after determining the best outcomes of the aforementioned experimental settings.

3. RESULTS AND DISCUSSIONS:

3.1 EFFECT OF PH:

The maximal uptake of methylene blue at pH 10 is shown in Chart 3.1(a) by maintaining the same concentration level of 100 ppm with 1 g of room temperature adsorbent. Adsorption in relation to the surface groups on the adsorbent is impacted by the pH of the adsorbate. Therefore, the pH of 9 is thought to be ideal for further research.

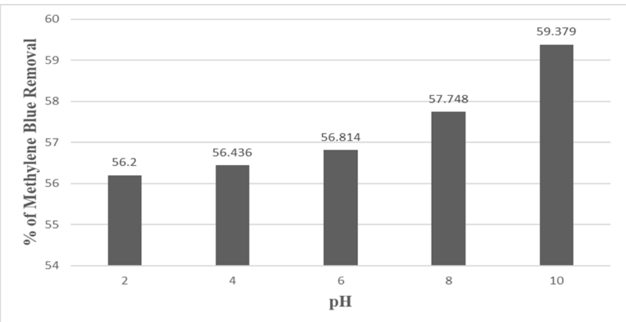

Chart 3.1(a) Graph showing percentage removal w.r.t pH

3.2 EFFECT OF ADSORBENT DOSAGE:

To evaluate the impact of an increase in adsorbent dosage on removal efficiency, a batch adsorption method was calculated. Different adsorption dosages, including 0.5g, 1.0g, 1.5g, 2.0g, and 2.5g, were added to the solutions. The solution concentration was held at 100 ppm, while the contact time was held at 120 minutes. The experiment's findings are shown in the graphic below. From 0.5g to 2.5g, the removal efficiency steadily rose. Later, for 2.5g, the removal efficiency reached to 99.575 percent (Chart 3.2(a)).

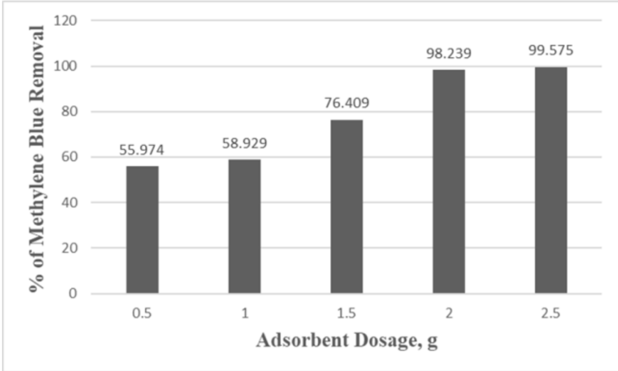

Chart 3.2(a) Graph showing percentage removal w.r.t adsorbent dosage

3.3 EFFECT OF INITIAL CONCENTRATION:

Batch adsorption process was carried out to check the effect of initial concentration on the removal efficiency. Different concentration such as 20ppm, 40ppm, 60ppm, 80ppm, 100ppm, 120ppm, 140ppm, 160ppm were prepared and adsorption experiment was conducted. The removal efficiency was 99.659% for 20ppm and it constantly decreased when the concentration was increased. It went up to 40.654% for 160ppm (Chart 3.3(a)).

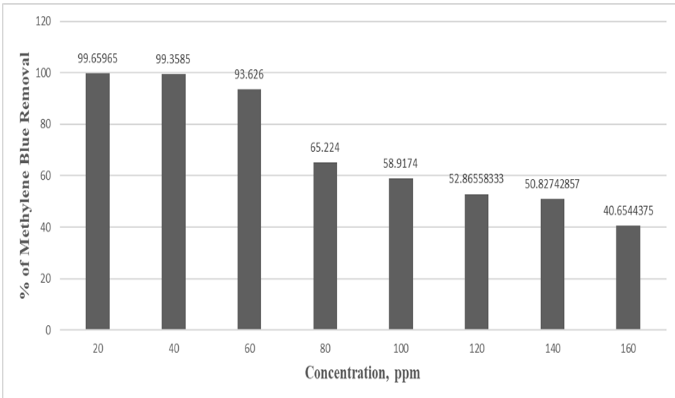

Chart 3.3(a) Graph showing percentage removal w.r.t Initial concentration

3.4 EFFECT OF CONTACT TIME:

The contact times chosen were 30, 45, 60, 120, 180, 240, and 300 minutes. 1g of adsorbent was added to each sample, and the solution concentration was kept at 100 ppm. The experiment's findings are shown in the graphic below. When the contact duration was increased from 30 minutes to 180 minutes, the adsorption of the Methylene Blue dye increased from 54.9770 percent to 97.1904 percent. After 300 minutes of contact time, it increases to a maximum of 97.3510 percent.

It was observed that the initial period's strong adsorption rate persisted for 180 minutes. However, as the time is extended past 180 minutes, it displays a steady value for 240 minutes and 300 minutes. Therefore, it indicates that there are no active sites on the adsorbent's surface (Chart 3.4(a)).

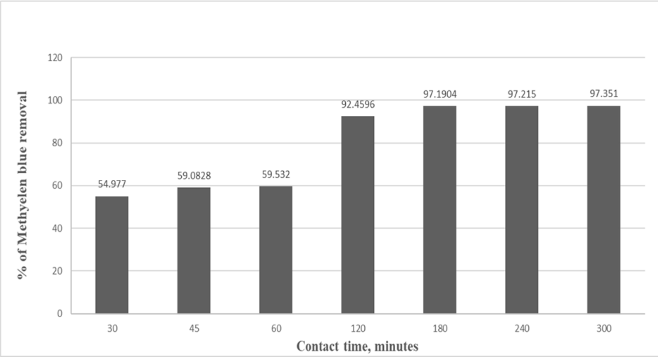

Chart 3.4(a) Graph showing percentage removal w.r.t Contact time

4. CONCLUSION:

The removal of dyes from water bodies that are discharged by companies is possible using a variety of approaches, but adsorption is one that is both successful and affordable. Numerous naturally occurring adsorbents have demonstrated their effectiveness in removing different colours from wastewater. Wastewater should be cleaned of dangerous chemicals like the hazardous Methylene Blue dye. Watermelon rind that has been activated may be able to absorb the dye Methylene Blue.

Watermelon rind provides the highest percentage clearance of 97 to 99 percent. It will be a positive step to use readily accessible natural adsorbents to remove damaging colours like Methylene blue. The adsorbent's adsorption capability may be improved by proper activation.

REFERENCES

[1]. Aswathy Mohan, Anjali S, (2019), "Study of sugarcane bagasse and orange peel as adsorbent for treatment of industrial effluent contaminated with nickel", International Research Journal of Engineering and Technology, Vol. 4, 4725-4731.

[2]. Ali H. Jawad, R Razuan, Jimmy Nelson Appaturi, Lee Wilson, (2019), "Adsorption and mechanism study for methylene blue dye removal with carbonised watermelon (Citullus lanatus) rind prepared via one-step liquid phase H_2SO_4 activation", Surfaces and Interfaces, http://doi.org/10.1016/j.surfin.2019.04.012.

[3]. Dibyashree Shrestha, (2021), "Efficiency of Wood-Dust of Dalbergia sisoo as Low-Cost Adsorbent for Rhodamine-B Dye removal", Nanomaterials, http://doi.org/10.3390/nano11092217.

[4]. Kayoda Adebowale, Abisola Egbedina, Blessed Shonde, (2020), "Adsorption of lead ions on magnetically separable Fe_3O_4 watermelon composite", Applied Water Science, 10:225.

[5]. M. I. S. Jebamani, M. K. Saseetharan, (2005), "Adsorption Batch Studies on Activated Carbon in Removing Nickel and Lead", Indian Journal on Environmental Protection, Vol. 25, No. 9, 809-815.

[6]. Nagy E. and Borbely G. (2009), "Removal of Zinc and Nickel Ions by Complexation Membrane filtration Process from Industrial Wastewater". Desalination, Vol. (240), 218-226.

[7]. Osama M. Darwesh, Aya H. Abd El-Latief, Mohamed E. Aburab, Mohamed A. Kasem, (2020), "Enhancing the efficiency of some agricultural wastes as low-cost absorbents to remove textile dyes from contaminated solutions", Biomass Conversion and Biorefinery, http://doi.org/10.1007/s13390-020-01142-w.

[8]. R. Laksmipathy, Nirmala Anvesh Reddy, N. C. Sarada, (2014), "Optimization of Brilliant green biosorption by native and acid-activated watermelon rind as low-cost adsorbent", Desalination and Water Treatment Publications, http://doi.org/10.1080/19443994.2013.879082, 235-244.

[9]. S. Senthilkumar, P R Varadarajan, K Porkodi, C V Subbhuraam, (2005), "Adsorption of Methylene blue onto jute fibre carbon: kinetics and equilibrium studies", Journal of Colloid and Interface Science, 78-82.

[10]. Seema, Anil Yadav, Mamta Bhagat, Virender Yadav(2017) "Congo Red Dye Removal From Aqueous Solution Using Activated Orange Peel", International Journal of Engineering Technology Science and Research, Volume 4, Issue 12.

[11]. Youzhou Zhou , Liuqin G E, Neng Fan, (2018), "Adsorption of Congo red from aqueous solution onto shrimp shell powder", Adsorption Science & Technology 0(0) 1–21.

[12]. X. Cuong Nguyen, T. Thanh Huyen Nguyen, T. Hong Chuong Nguyen, et.al, (2020),"Sustainable carbonaceous biochar adsorbents derived from agro-wastes and invasive plants for cation dye adsorption from water", Chemosphere, 282, 131009.

[13]. Y.C.Wong , K.N. Ranjini And W.A.Wan-Nurdiyana (2014), "Removal of Congo Red and Acid Yellow 36 Dye Using Orange Peel and Rice Husk as Absorbents", Oriental Journal Of Chemistry, Vol. 30, No. (2).