RESEARCH ARTICLE

Removal of Pollutants from Aqueous Solutions by using Natural Surfaces (Cotton) as a Model for Reusability and Highly Adsorbent Surface

Aseel M. Aljeboree[1]*, Noora M. Hameed[2], Hayder D. Saleem[3], Hadeer Jasem[4], Emad S. Abood[5], Athraa G. Abdulrazaq[6], Ahmed K. O. Aldulaim[7], Ayad F. Alkaim[1]

[1]*Department of Chemistry, College of Sciences for Girls, University of Babylon, Hilla, Iraq*
[2]*Department of Anesthesia Techniques, Al-Nisour University College, Baghdad, Iraq*
[3]*Al-Manara College for Medical Sciences, Maysan, Iraq*
[4]*Department of Medical Instrumentation Techniques Engineering, Al-Mustaqbal University College, Babylon, Iraq*
[5]*Department of Medical Physics, Hilla University College, Babylon, Iraq*
[6]*Al-Esraa University College, Baghdad, Iraq*
[7]*Department of Pharmacy, Al-Zahrawi University College, Karbala, Iraq*

Received: 19th February, 2022; Revised: 16th April, 2022; Accepted: 26th May, 2022; Available Online: 25th June, 2022

ABSTRACT

In this study, four types of textile dyes (Congo red CR, Maxellon blue GRL, crystal violet CV, Brilliant blue BB) were adsorbed from their aqueous solution using cotton as a highly efficient adsorbent surface. The method relied on using a syringe as a separating column, and the syringe was filled with cotton within a certain weight. The most crucial factors affecting the separation process were studied, including the effect of weight, and the effect of concentration of dyes. The surface (reusability) reuse was also studied several times in the separation process. It was found that the cotton keeps its efficiency after three cycles, but after the fourth cycle, it loses its efficiency as an effective adsorbent surface. The two types of adsorption isotherms were applied through the results that the Freundlich adsorption isotherm depending on the value of (Congo red CR, Maxellon blue GRL, crystal violet CV, Brilliant blue BB) dyes (R^2= 0.9788, 0.9591, 0.9423, 0.9122) compared to the Langmuir isotherm.

Keyword: Adsorption, Isotherm model, Pollution reusability, Removal, Textile dyes.

International Journal of Drug Delivery Technology (2022); DOI: 10.25258/ijddt.12.2.20

How to cite this article: Aljeboree AM, Hameed NM, Jasem H, Saleem HD, Abood ES, Abdulrazaq AG, Aldulaim AKO, Alkaim AF. Removal of Pollutants from Aqueous Solutions by using Natural Surfaces (Cotton) as a Model for Reusability and Highly Adsorbent Surface. International Journal of Drug Delivery Technology. 2022;12(2):583-587.

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Water is one of the essential ingredients required in the continuity of life for all living things. However, in the recent period, it has become very difficult to maintain pure water free of organic and inorganic pollutants such as phenols and their derivatives, as well as insecticides and heavy metals, as well as due to waste from dyes and pharmaceutical factories, and hospital waste.[1-3] Dyes are toxic pollutants due to their toxicity and presence in water in high concentrations. Dyes have become a threat to the life of living organisms and cause many diseases and also reduce the aesthetic value of the nature of water bodies, leading to unnatural differences in aquatic ecosystem.[4,5]

Maxilon Blue GRL dye is a basic dye with chemical formula: C20H26N4O6S2, chemical structure shown in Figure 1 a), wavelength λ_{max}= 599 nm.[6-8]

Brilliant blue BB dye the chemical Formula: C37H34N2Na2O9S3 and Molar mass: 792.85 g/mol, a synthetic organic compound utilized primarily as color blue of processed foods, medications, cosmetics and dietary supplements, and. It is classified as a triarylmethane dye (Figure 1b).[9,10]

Congo red CR dye as shown in the Figure 1 c, is an organic compound, the sodium salt 3,3'-bis. It is an azo dye. Congo red has a high solubility in water and is produced when a red colloidal solution is dissolved. It is also characterized by its high solubility in organic solvents. However, in the recent period, the use of Congo red has become very little due to its very toxic and carcinogenic properties.[11-13]

Crystal violet CV dye belongs to the class of dyes triphenylmethane as shown in the Figure 1 d) is widely used in veterinary medicine and also for skin disinfection. Crystal violet is a toxic dye. When ingested or inhaled, it causes skin.[14-16]

**Author for Correspondence: annenayad@gmail.com*

EXPERIMENTAL PART

Cotton was provided from Iraqi markets (as a natural plants), the textile dyes (Congo red dye CR, Crystal Violet CV, Maxilon Blue GRL, Brilliant blue BB) were obtained from the Hilla Textile Factory in Iraq. The stander solutions (1000 mg/L) were prepared for each dye by dissolving weight (1.0 g) in 100-mL distilled water.

To calculate the maximum wavelength of the textile dyes (Congo red dye CR, Crystal violet CV, Maxilon blue GRL, Brilliant blue BB), the ultraviolet-visible absorption spectra of dyes solution was recorded within wavelengths of 200-800 nm. λ_{max} CV = 590 nm, λ_{max} CR = 565 nm, λ_{max} BB = 630nm, λ_{max}GRL = 595 appear in Figure 2.

The calibration curve of different concentration of each textile dyes (Congo red dye CR, Crystal Violet CV, Maxilon Blue GRL, Brilliant blue BB) were prepared in serial dilutions (2–100 mg/L). Absorbance was measured at the λ_{max} for each textile dyes and plotted against the concentration values of CV, CR, GRL, BB as appear in (Figure 3).

Effect of Several Factor on the Adsorption Process

Effect Weight of Cotton

The study was conducted with several weight (0.05, 0.1, 0.2, 0,3) g for (Cotton). The concentrations of (Congo red CR, Crystal violet CV, Maxilon blue GRL, Brilliant blue BB) dyes the samples were 50 mg.L^{-1}. at a fixed temperature 25°C at pH 6.6, the remaining dye concentration in the aqueous phase is measured spectro-photometrically for the chosen wavelength.

Effect of Concentration Dyes

A series of several concentrations of 10 mL for (Congo red CR, Crystal Violet CV, Maxilon Blue GRL, Brilliant blue BB) dyes has been used in this study (10, 20, 30, 40, 50, 60, 70, 80 and 100) mg.L^{-1}, was added to a syringe as a separating column, and the syringe was filled with cotton within a certain weight in the presence of (0.1 g/50 mL) of cotton, after that the supernatant was separated by centrifuge and measured the remaining concentration by using UV-visible spectrophotometer for the chosen wavelength.

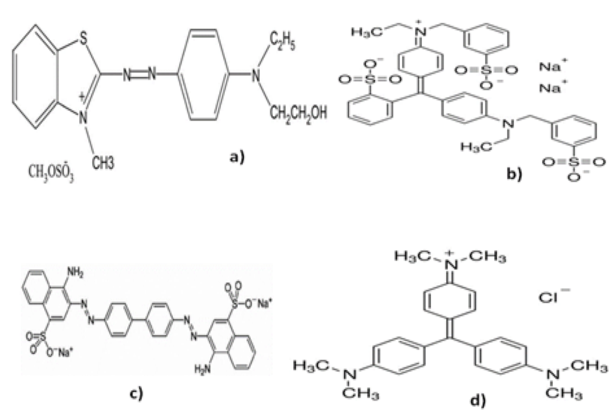

Figure 1: Chemical structure a) Maxilon blue GRL dye, b) Brilliant blue BB dye, c) Congo red dye CR, d) Crystal violet CV dye.

The adsorption efficiency and removal percentage was calculated in equation (1,2):[17,18]

$$qe = \frac{(C_0 - C_e) * V_L}{m_{gm}} \quad (1)$$

$$E\ \% = \frac{C_0 - C_e}{C_0} * 100 \quad (2)$$

Reusability

Reusability and reactivity the cotton surface after the adsorption process that was conducted by washing several times by distilled water until the removed color of dye from the surface, to reactivating and using the surface again in the process of removing dyes. The adsorption cycle was repeated six additional times with 50 mL of dye solution at a concentration of 50 mg/L at 30°C.

RESULTS AND DISCUSSION

Effect of Weight

To investigate the variation in the removal percentage of (Congo red dye CR, Crystal violet CV, Maxilon blue GRL,

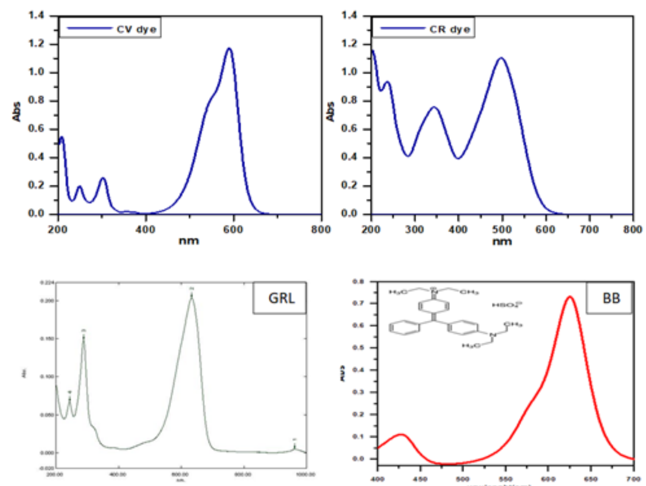

Figure 2: Maximum wavelength of the textile dyes (Congo red CR, Crystal Violet CV, Maxilon Blue GRL, Brilliant blue BB) dyes.

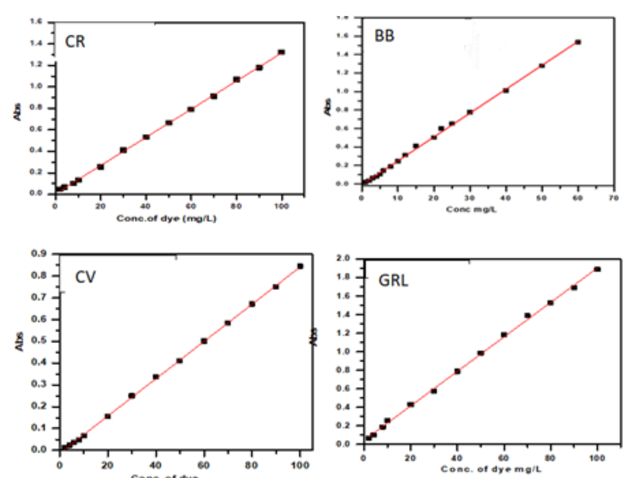

Figure 3: Calibration curve for (Congo red dye CR, Crystal violet CV, Maxilon blue GRL, Brilliant blue BB) dyes

Brilliant blue BB) onto several doses (0.05 to 0.3 gm) of cotton was used, and study were performed at constant concentration of dyes of 50 mg/ L, the respective data appear in Figure 4.

The adsorption capacity of (Congo red dye CR, Crystal violet CV, Maxilon blue GRL, Brilliant blue BB) decrease from (97.2–28.5 mg/g, 95.5–70.2 mg/g, 80.22–45.5 mg/g, 74.3–40.4 mg/g) respectively with increasing weight of cotton from 0.05 to 0.3 gm and removal percentage increased from (15.1–79.0%, 70-98%, 47.2–81.1%, 42.2–78.2%) respectively. Increase in the E% adsorption with adsorbent dose can be attributed to increased adsorbent surface area and presence of more adsorption sites.[19-21]

Effect of Initial Concentration of Dyes

The effect of concentration of (Congo red dye CR, Crystal violet CV, Maxilon blue GRL, Brilliant blue BB) on adsorption capacity and removal percentage of dyes was examined in the concentration of 10–100 mg/L, were obtained initial concentration of 50 mg /L for 50 mL of solution dyes as shown in Figure 5.

As shown, removal percentage E% (45, 78, 77 and 68%) for (Congo red dye CR, Crystal violet CV, Maxilon Blue GRL, Brilliant blue BB) onto cotton, respectively.[22,23]

Re-usability

Reusability and reactivity of cotton surface after the adsorption process that was carried out by washing several times by distilled water until the removed color of dye from the surface, to reactivating and using the surface again in the process of removing dyes. The adsorption cycle was repeated six additional times with 50 mL of dye solution at a concentration of 50 mg/L at 30°C as appear in Figure 6.

Through the results shown in the figure, it was found that the removal percentage remains almost constant during four cycles of the adsorption process, but after the fourth cycle, the removal percentage decreases because the surface loses its efficiency in removing pollutants.[14,24]

Adsorption Isotherm

The model Langmuer is most usually used of adsorption of dyes for liquid solution an additional equation was derived via the method of model Langmuer on the base of a definite case of the nature adsorption method from solution. The model Langmuir appears in Eq. 3

$$q_e = \frac{q_0 K_L C_e}{1 + K_L C_e} \quad (3)$$

The model Freundlich is appeared in Eq. 4

$$q_e = K_f C_e^{1/n} \quad (4)$$

Where qe is the adsorbent quantity adsorbed/unit weight at equilibrium ($mol.G^{-1}$), ($mg.g^{-1}$), Ce: the adsorbate equilibrium scam solution next adsorption ($mg.L^{-1}$), ($mol.L^{-1}$), Kf: capacity factor ($L.g^{-1}$), 1/n hetero-geneity parameter, n is a deviation measured of the deviation from adsorption linearity. Its value indicates a non-linearity unit between adsorption and concentration solution as follows: adsorption route is chemical if the value under the unity adsorption or it is linear if the n value equal to unity, finally the favorable physical route when the value is above the unity. A plot of qe vs Ce (Figure 7), where the values of KF and 1/n are obtained from the intercept and slope of the linear regressions.[25,26]

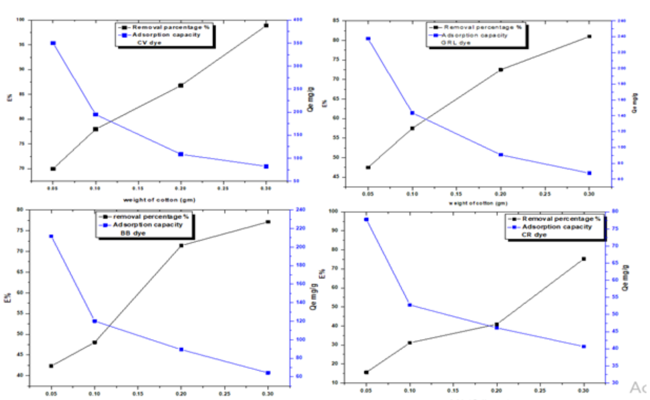

Figure 4: Effect of mass adsorbent on adsorption of (Congo red CR, Crystal Violet CV, Maxilon Blue GRL, Brilliant blue BB) dyes.

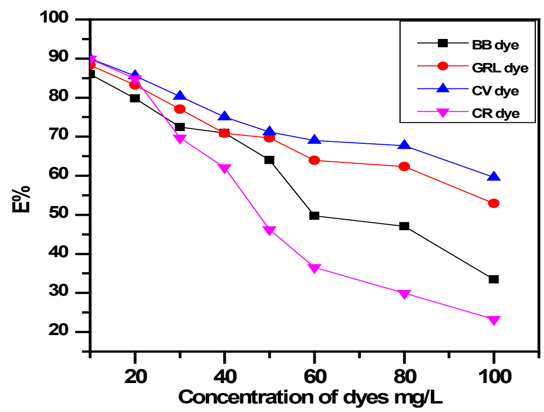

Figure 5: Effect of concentration of (Congo red CR, Crystal Violet CV, Maxilon Blue GRL, Brilliant blue BB)dyes on the removal percentage.

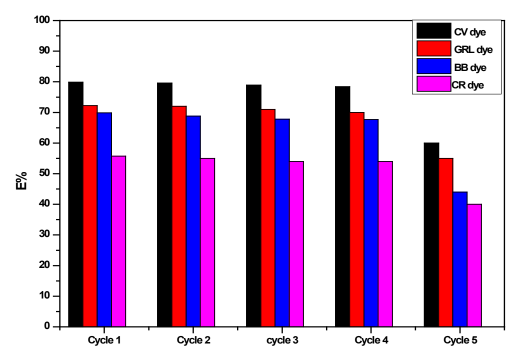

Figure 6: Reusability and reactivity of cotton surface after the adsorption process by (Congo red dye CR, Crystal Violet CV, Maxilon Blue GRL, Brilliant blue BB)

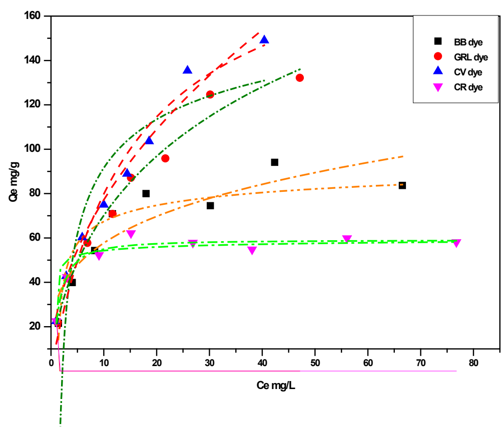

Figure 7: Several models adsorption Isotherm non-linear fit of adsorption of (Congo red dye CR, Crystal Violet CV, Maxilon Blue GRL, Brilliant blue BB) onto cotton.

CONCLUSION

In this work, it relied on the removal of four toxic textile dyes, The adsorption capacity of (Congo red CR, Crystal violet CV, Maxilon blue GRL, Brilliant blue BB) dyes decrease from (97.2–28.5 mg/g, 95.5–70.2 mg/g, 80.22–45.5 mg/g, 74.3–40.4 mg/g), were obtained initial concentration of 50 mg /L the removal percentage E% (45, 78, 77 and 68%) for (Congo red dye CR, Crystal violet CV, Maxilon blue GRL, Brilliant blue BB) onto cotton, Reusability and reactivity of cotton surface after the adsorption process by washing several times distilled water.

REFERENCE

1. Shouman M A .Studies on Adsorption of Basic Dyes on Activated Carbon Derived from Phragmites australis (Common Reed) Universal. Journal of Environmental Research and Technology. 2012; 2(3):119-134 .
2. Hadi Z A, Aljeboree A M, Alkaim A F. Adsorption of a cationic dye from aqueous solutions by using waste glass materials: Isotherm and thermodynamic studies. International Journal of Chemical Sciences. 2014; 12(4):1273-1288 .
3. Al-Gubury H Y, Fairooz N Y, Aljeboree A M, Alqaraguly M B, Alkaim A F. Photcatalytic degradation n-undecane using coupled ZnO-Co2O3. International Journal of Chemical Sciences. 2015; 13(2): 863-874.
4. Aljeboree A M, Alshirifi A N, Alkaim A F, Removal of pharmaceutical amoxicillin drug by using (Cnt) decorated clay/ fe2 o3 micro/ nanocomposite as effective adsorbent: Process optimization for ultrasound assisted adsorption. International Journal of Pharmaceutical Research. 2019; 11(4):80-86.
5. Salleh M, Mahmoud D K,Karim W A. Cationic and anionic dye adsorption by agricultural solid wastes: A comprehensive review. Desalination.2021; 280(3): 1-13.
6. Enas M A, Abrar M A, Aseel M A, Ayad F A, Falah H H. Investigation of photocatalytic removal and photonic efficiency of maxilon blue dye GRL in the presence of TiO2 nanoparticles. Particulate Science and Technology.2017; 35(1): 14-20.
7. Alqaragully M B. Removal of Textile Dyes (Maxilon Blue, and Methyl Orange) by Date Stones Activated Carbon International Journal of Advanced Research in Chemical Science.2014; 1(1): 48-59
8. Aseel M A, Nadher D R, Layth S. J,Ayad F A .Removal of Pharmaceutical by Adsorption Process; Study Effect of Various Parameters and Determination of Pharmaceutical by Oxidative Coupling Reaction. International Journal of Drug Delivery Technology. 2021; 11(3): 912-916.
9. Gecgel U K. Adsorption of Remazol Brilliant Blue R on activated carbon prepared from a pine cone. Nat Prod Res. 2012;26: 659-664.
10. Saleh M. Optimization of Remazol Brilliant Blue R Adsorption onto Xanthium Italicum using the Response Surface Method Karbala International Journal of Modern Science. 2019; 5(1):DOI: 10.33640/2405-609X. 1017.
11. Kamil A M, Mohammed H T, Alkaim A F,Hussein F H .Adsorption of Congo red on multiwall carbon nanotubes: Effect of operational parameters. Journal of Chemical and Pharmaceutical Sciences.2016;9(3): 1128-1133.
12. Wycliffe J M, Paul M S. Adsorption of Congo Red Dye from Aqueous Solutions Using Roots of Eichhornia crassipes: Kinetic and Equilibrium Studies. Energy Procedia .2014; 50: 862-869.
13. Arif K, Afaq M, Ravi C, Sahid H. Metal nanoparticles decorated phosphorylated carbon nanotube cyclodextrin nanosponge for trichloroethylene and Congo red dye adsorption from wastewater. 2020;11(2):https://doi.org/10.1016/j.colsurfa.2020. 125868.
14. Aseel M A, Ayad F A. Role of plant wastes as an ecofriendly for pollutants (Crystal Violet dye) removal from Aqueous Solutions Plant Archives 2019 ;19(2): 902-905.
15. Fabryanty R, Valencia C, Edi Soetaredjo F, Shella P i S, Suryadi A K. Removal of crystal violet dye by adsorption using bentonite – alginate composite. Journal of Environmental Chemical Engineering, 2017; 5: 5677–5687.
16. Aseel M A, Ayad F A, Ali l, hanadi M A. Photocatalytic Degradation of Textile Dye Cristal Violet Wastewater using Zinc Oxide as a Model of Pharmaceutical Threat Reductions. Journal of Global Pharma Technology. 2019; 11(02): 138-143.
17. Ahmad R. Studies on adsorption of crystal violet dye from aqueous solution onto coniferous pinus bark powder (CPBP). J. Hazard. Mater. 2009; 171: 767-773.
18. Doğan M, Alkan M, Demirbas O, Ozdemir Y, Ozmetin C.Adsorption kinetics of maxilon blue GRL onto sepiolite from aqueous solutions. Chem. Eng. J.. 2006; 124: 89-101.
19. Mohammed A J, Abed J K, Nadher D. R. Role of Sodium Alginate-g-poly (Acrylic acid-fumaric acid) Hydrogel for Removal of Pharmaceutical Paracetamol from Aqueous Solutions by Adsorption. International Journal of Pharmaceutical Quality Assurance. 2021; 12(3): 202-205.
20. Giphin G. Facile synthesis of carbon-coated layered double hydroxide and its comparative characterisation with Zn–Al LDH: application on crystal violet and malachite green dye adsorption—isotherm, kinetics and Box-Behnken design. Environmental Science and Pollution Research.2019. 1: https:// doi.org/10.1007/s11356-018-3001-3.
21. Akeem A O. Enhanced removal of crystal violet by low cost alginate/acid activated bentonite composite beads: Optimization and modelling using non-linear regression technique. journal of Water Process Engineering.2019. 2:43-52.
22. Aljeboree A M, Alshirifi A N,Alkaim A F. Activated carbon (as a waste plant sources)-clay micro/nanocomposite as effective

adsorbent: Process optimization for ultrasound-assisted adsorption removal of amoxicillin drug. Plant Archives .2019; 19: 915 - 919.

23. Yahya A F, Nadher D R .Removal of Metformin hydrochloride from Aqueous Solutions by using Carboxymethyl celluloseg-poly(acrylic acid-co-acrylamide) Hydrogel: Adsorption and Thermodynamic Studies. IOP Conf. Series: Earth and Environmental Science .2021; 790: 012062.
24. Aljeboree A M, Alkaim A F. Removal of Antibiotic Tetracycline (TCs) from aqueous solutions by using Titanium dioxide (TiO2) nanoparticles as an alternative material. Journal of Physics: Conf. Series 2019;1294 :052059.
25. Layth S J, Aljeboree M A. Removal of Heavy Metals by Using Chitosan/ Poly (Acryl Amide-Acrylic Acid)Hydrogels: Characterization and Kinetic Study. NeuroQuantology. 2021;19(2): 31-37.
26. Wared S H H, Nader D R .Synthesis and characterization of sodium alginate-g-polyacrylic acid hydrogel and its application for crystal violet dye adsorption. International Journal of Drug Delivery Technology.2021;11(2): 556 - 565.