International Journal of Computational and Experimental Science and ENgineering (IJCESEN)

Vol. 11-No.2 (2025) pp. 3016-3022

http://www.ijcesen.com

ISSN: 2149-9144

Research Article

Modification Of Natural Materials And Their Use By Adsorption

Walaa Jubair Sabbar*

Directorate General of Education in Baghdad (Karkh1), Baghdad, IRAQ.
* **Corresponding Author Email:** walaa.jabeer1205a@ihcoedu.uobaghdad.edu.iq - **ORCID:** 0000-0002-5247-785X

Article Info:

DOI: 10.22399/ijcesen.2130
Received : 05 January 2025
Accepted : 01 May 2025

Keywords

Methyl Green (MG)
Activated Pomegranate Peels (PPACT)
Activated Date Kernels (DPACT)
Adsorption
Thermal Equilibrium Study

Abstract:

This study aimed to investigate the removal of methyl green (MG) dye from aqueous solution on activated pomegranate peels and low-cost activated date kernels as an effective adsorbent sourced from Iraq. The two surfaces of the absorbent materials were examined using a scanning electron microscope (FESEM) and the dose of the adsorbent was determined. The process of adsorption of MG on the two surfaces was an endothermic process, and the adsorption capacity increased with increasing doses of adsorbents. Also, a number of adsorption isotherms were applied, such as (Langmuir, Freundlich) for this study, where it was found The process of dye (MG) adsorption on the two surfaces follows the Langmuir model.

1. Introduction

Fast urbanization, moving utilization designs, populace extension, and accelerated paces of financial advancement have all added to expanded water contamination in the biosphere, [1]. Water is viewed as the best and focal substance in human existence. Because of its significant applications in different ventures, water is presented to a few poisons and can thusly be tainted. As of late, water contamination has turned into a significant danger to water biology, and in this manner the extraction of poisons from modern wastewater prior to releasing into water streams is fundamental [2] Colors, weighty metals, cyanide, harmful organics, nitrogen, phosphorus, phenols, and suspended particles are unmistakable reasons for contamination in regular water from private and modern tasks, which are fit for changing the shade of water [3] Adsorption innovation is viewed as a powerful color expulsion strategy in which color particles are joined to the outer layer of the adsorbent materials. In this way, there is interest in utilizing the reasonable and accessible color evacuation materials to adsorb the colors [4] Where these modest materials are found and accessible in nature or may come from modern and agrarian waste, it very well might be usable as adsorbent materials that can be discarded in the wake of involving them in adsorption since they are cheap.A wide assortment of materials such Actuated carbon [5] pomegranate peel [6,7] and date pits [8,9] This study aimed to modify natural materials at the lowest cost from agricultural waste, pomegranate peels and date pits. To adsorb methyl green (MG) dye contaminated with water.

2. Expermental

2.1 Adsorbate Methyl green (MG) dye properties

Wastewater was used as an adsorbate, with a maximum wavelength (λ max) of 618 nm, as seen in Figure 1 [10]. The molecular formula is $C_{26}H_{33}N_3Cl_2$, and the chemical structure of Methyl Green is depicted in Figure 2. [11], A stock solution (100 mg/L) was created by dissolving 0.1 g of methyl green dye in 1 L of distilled water, followed by dilution to get the appropriate concentration.

2.2 Preparing activated carbon (ACT) using pomegranate peels (PP) and date pits (DP)

Pomegranate peels (PP) were washed, then placed in the sun to dry for several days, then they were placed in an electric oven at 150°C, then ground finely, and then they were activated by adding carbon from charcoal and acetic acid, stirring and leaving it for a period of time, then dried at a temperature of 100 °C.To obtain the powder from activated pomegranate peels (PPACT), which is used in the experiment, as shown in the diagram (1), it includes the step of preparing activated carbon from the pomegranate peels. In the same previous way, the activated date pits (DPACT) was prepared, as shown in the diagram (2).

2.3 Description of adsorbents

The scanning electron microscope device (FESEM) model (MIRA3 TESCAN) is used to examine the surface appearance of activated carbon produced from Activated pomegranate peels (PPACT) and Activated date pits (DPACT) .

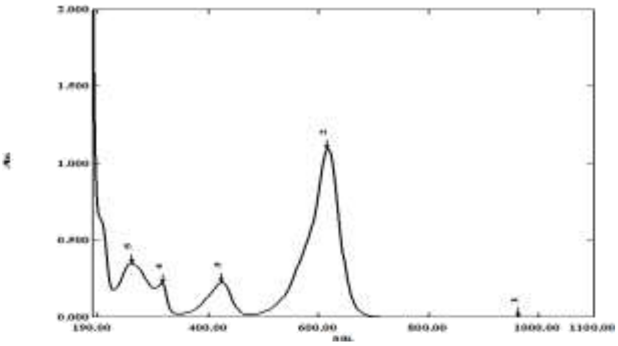


Figure 1. *UV-V absorption spectrum of the dye methyl green (MG)*

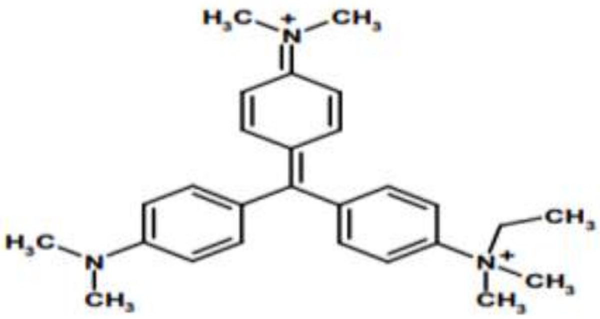


Figure 2. *Chemical structure of Methyl green dye (MG)*

Scheme 1. *Includes the steps for preparing activated carbon from pomegranate peels (PPACT)*

Scheme 2. *Includes the steps for preparing activated carbon from date pits (DPACT).*

2.4 Adsorption Study

To perform the adsorption process, multiple weights were taken from the adsorbent surface to determine the appropriate weight, which is: (0.01 , 0.015 , 0.02 , 0.03) g These weights were placed in four beakers, with each beaker having its own size (50 ml) with the addition of (10 ml) of dye solution Methyl green (MG) with focus (50 mg/L) then put it in a controlled shaking water bath at a temperature of (298 K) and quickly (rpm 120) for an hour, then it was placed in a test tube, after which it was placed in a centrifuge For a period of (10 min) and at a speed of (5000 rpm), then (5 ml) was taken and its absorbance was measured using an ultraviolet-visible (UV/Vis) spectrometer at the wavelength of the dye (MG) the amount of adsorbed material was determined according For the surface of active pomegranate peels (PPACT) and active date pits (DPACT) to the following equation (1). [12].

$$q_t = \left(\frac{C_0 - C_t}{m}\right) \cdot V_{sol} \qquad (1)$$

In this context, qt denotes the quantity of adsorbed material at time t (mg/g), whereas m signifies the surface weight of the adsorbent material (g). Co: initial concentration of the solution (mg/L). Ct: concentration of the solution at time t (mg/L); V: total volume of the adsorbent solution (L).

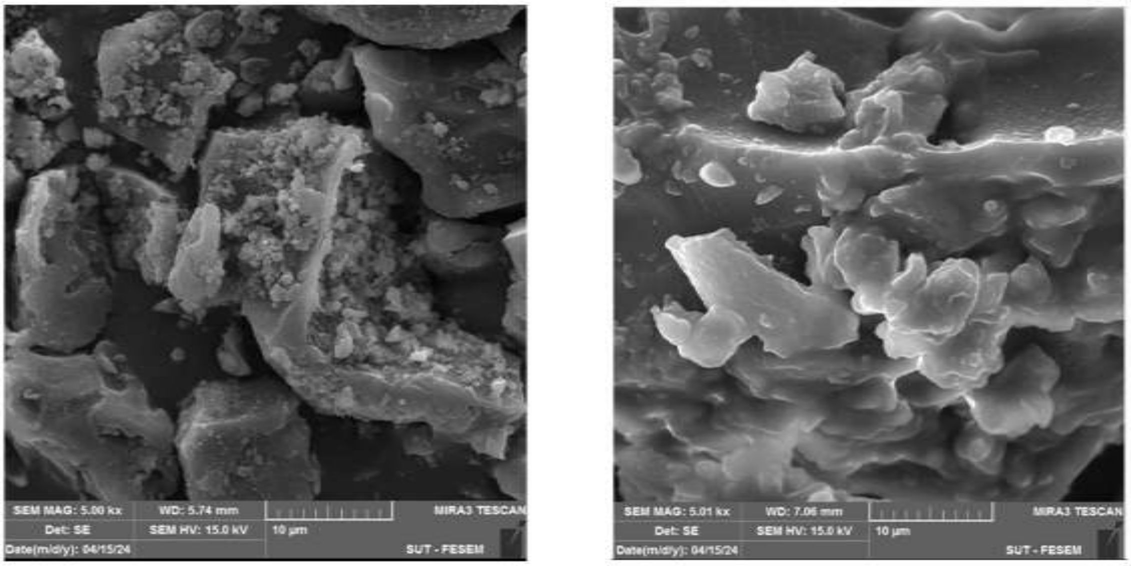
3. Results and Discussion

3.1 Field-emission Scanning electron microscope (FESEM)

It was employed to analyse the pore structure of activated carbon. The pores of activated carbon function as active sites for adsorption. Scanning electron microscope images of activated carbon obtained from active pomegranate peels (PPACT) and active date pits (DPACT) post-activation. The picture is presented in Figure (3) at a magnification of 10 µm. It contains pores present in the activated carbon for adsorption to occur. [13]

3.2 Effect of Adsorbent Weight

The effect of changing the weight of the adsorbent on the adsorption process was studied, as shown in Figure (4), by using a fixed concentration of (MG) dye at different weights of the adsorbent surfaces (active pomegranate peels (PPACT) and active date pits (DPACT)). At a temperature of 298 K. It was observed from Figure (4) that the adsorbed amount of (MG) dye increases with the increase in weight of the adsorbing surfaces of the two surfaces that were studied. This is a result of the increase in the



a- PPACT b- DPACT

Figure 3. *shows a FESEM image of the surface of (a) active pomegranate peels (PPACT) and (b) active date pits (DPACT)*

number of unoccupied and effective adsorption sites for dye adsorption, so that its highest value is at a weight of (0.03 g) at all surfaces, that is, they reach a specific value that represents the amount of adsorbed material at the saturation stage of the amount of adsorbed material of the (MG) dye. [14].

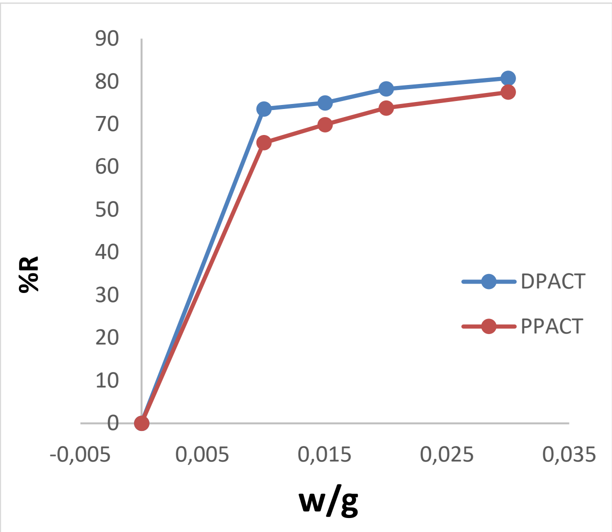


Figure 4. *shows the effect of changing the weight of the adsorbent surface (active pomegranate peels (PPACT) and active date pits (DPACT)) on the adsorption of (MG) dye at a temperature of (298) K*

3.3 Find The Percentage of Adsorption

The percentage of adsorption of MG dye from its aqueous solution onto Biplane (PPACT, DPACT) was determined at different temperatures (293, 298, 303,308)K. The following equation was used. [15].

$$A\% = \frac{C_0 - C_t}{C_0} * 100 \qquad (2)$$

Where: A% represents the adsorption percentage, C_0 denotes the starting concentration of the dye in milligrammes per litre (mg/L), and Ct indicates the concentration of the dye at time (t) in milligrammes per litre (mg/L).

The adsorption percentage (A%) was graphed against the contact time (t) between the dye solution (MG) and the adsorbent surfaces (PPACT, DPACT) at various temperatures (293, 298, 303, 308) K, as illustrated in Figure (5). The adsorption rate rises with rising temperature, indicating that the adsorption of the dye (MG) on all examined surfaces is more effective at elevated temperatures. This indicates that the nature of the adsorption (endothermic) on the one hand, and on the other hand, that the best is efficiency in the adsorption of the dye. (MG) is the surface of (DPACT). [16].

3.4 Isotherms

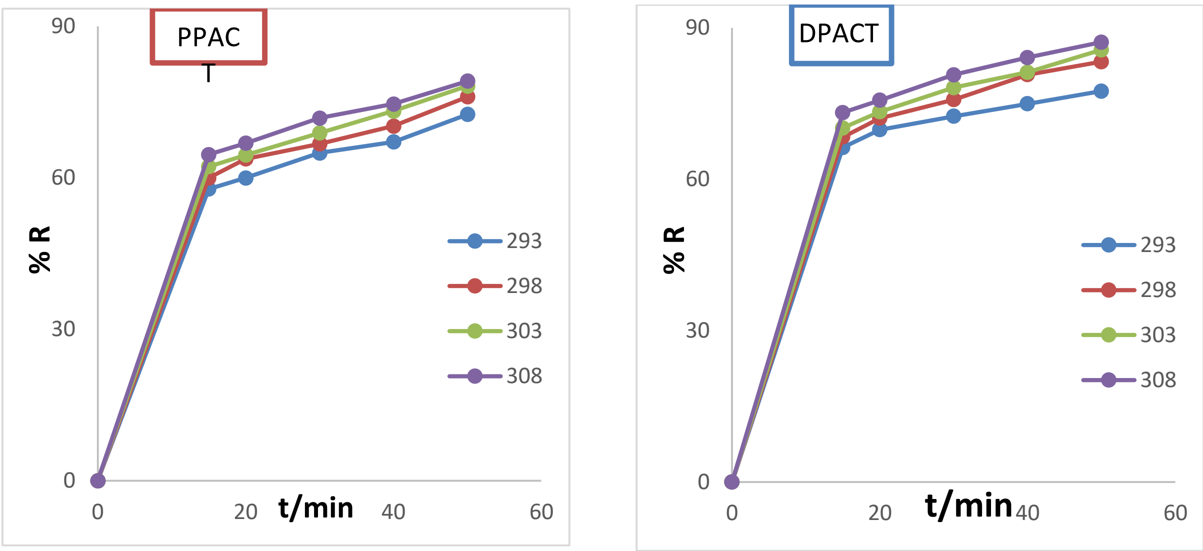
3.4.1 Langmuir Model

Adsorption is a process characterized by homogeneity, wherein a single layer of adsorbate is formed on the surface of the absorbent plane. This layer is brought about by the uniform energy distribution, as illustrated in the subsequent equation.

$$q_e = \frac{q_{max}\ K_L C_e}{1 + K_L C_e} \qquad (3)$$

The linear form of the equation is expressed as follow[17].

$$\frac{C_e}{q_e} = \frac{1}{q_{max} K_L} + \frac{C_e}{q_{max}} \qquad (4)$$



a- **PPACT** b- DPACT

Figure 5. *shows the percentage of adsorption of the MG dye at different temperatures to the surfaces (a) (PPACT) and (b) (DPACT)*

Where :- k_L: Langmuir constant (L/mg), q_{max}: Maximum amount of adsorbent (mg/g), q_e: amount of adsorbed substance at equilibrium (mg/g), C_e: concentration of adsorbent at equilibrium (mg/L) The linear Langmuir equation (4) was applied to experimental data for the adsorption of (MG) dye on two surfaces (PPACT) and (DPACT) at different temperatures (293, 298, 303,308)K, where the Langmuir constants were calculated through the slope and intercept of the straight line. The result is from plotting (Ce /qe) versus (Ce) as in Figure (6), and the constants of the Langmuir model are listed in Table (1).

3.4.2 Frendlich Model

It is one of the old and well-known relationships that is used to describe the adsorption process. This model applies to adsorption processes on heterogeneous surfaces and is used to describe multi-layer adsorption, not just single-layer adsorption. It is also based on heterogeneous adsorption systems. As shown in the following equation [18]

$$q_e = k_f\, C_e^{1/n} \qquad (5)$$

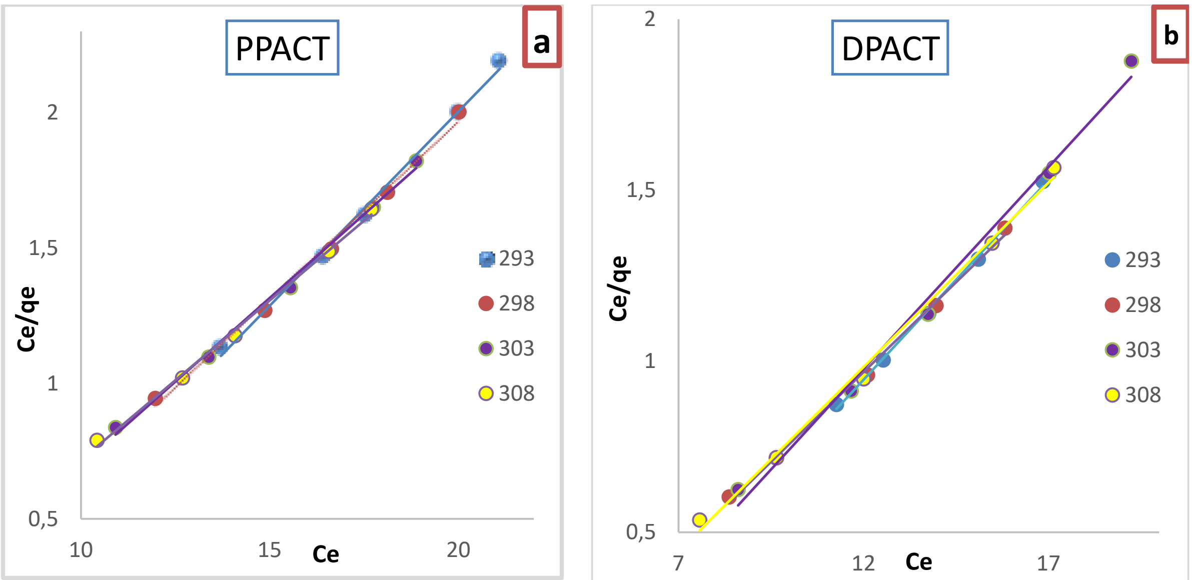
The linear form of the equation is expressed as follows:

$$\ln q_e = \ln k_f + \frac{1}{n} \ln C_e \qquad (6)$$

Where: kf represents the Freundlich constant, indicating adsorption capacity (mg/g); n denotes the measure of adsorption intensity; qe signifies the quantity of adsorbed material at equilibrium (mg/g); Ce refers to the concentration of the adsorbent at equilibrium (mg/L).The linear Freundlich equation (6) was applied to experimental data for the adsorption of (MG) dye on two surfaces (PPACT) and (DPACT) at different temperatures (293, 298, 303,308) K, where the Freundlich constants were calculated through the slope and intercept of the straight line. The result is a plot of (lnqe) versus (lnCe) as in Figure (7), and model constants are included in Freundlich Table(1). It has been shown that the adsorption of (MG) dye to two surfaces (PPACT, DPACT) is more suitable for the Langmuir isotherm model. [19].

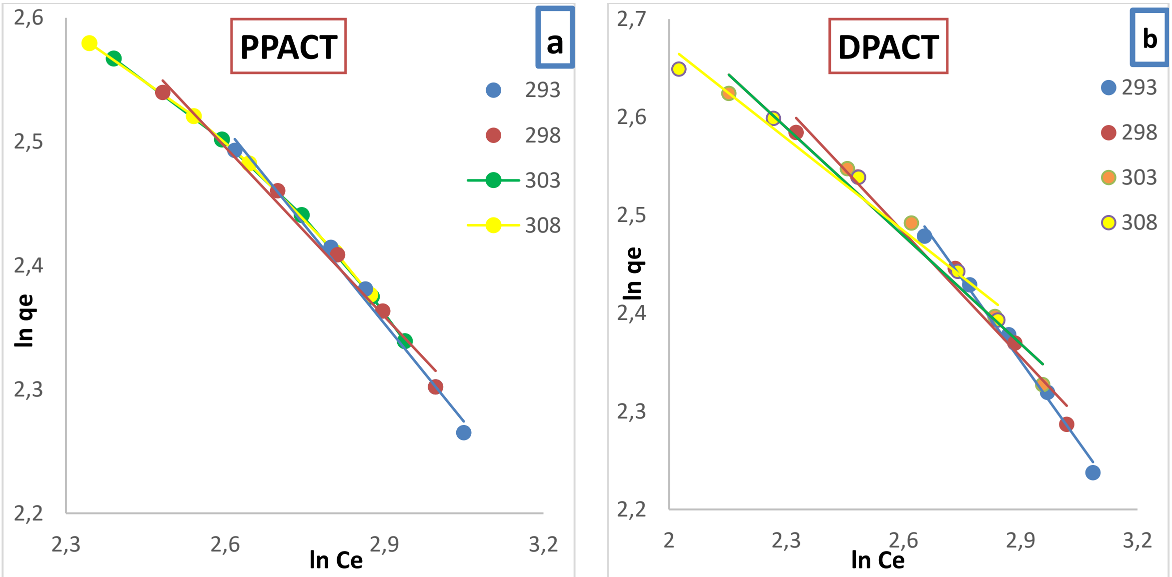
4. Conclusion

In conclusion, the study confirms the increased effectiveness of activated pomegranate peel and activated date kernel sorbents as the cationic methyl green (MG) dye was removed from aqueous solutions. It became clear that as the weight of the adsorbed surface of the two surfaces (PPACT, DPACT) increases, the adsorbed amount of (MG) dye increases, and from studying the effect of temperature on the adsorption of (MG) dye to the two surfaces (PPACT, DPACT), the amount of adsorbed dye increases with the increase in temperature, and this indicates that The process of adsorption of (MG) dye is of the endothermic type. It was noted from the percentage of adsorption that the highest percentage of adsorption of (MG) dye is on the (DPACT) surface, where it is the most efficient, then it is followed by the (PPACT) surface. It was found that the adsorption of (MG) dye to two surfaces (PPACT, DPACT) is more suitable for the Langmuir isotherm model. Low cost surfaces were obtained to improve aquatic environment treatment techniques.



a- **PPACT** b- DPACT

Figure 6. *represents the Langmuir isotherm for the adsorption of a dye (MG) on two surfaces (a) (PPACT) and (b) (DPACT) at different temperatures*



a- **PPACT** b- DPACT

Figure 7. *represents the Freundlich isotherms for the adsorption of (MG) dye on two surfaces (a) (PPACT) and (b) (DPACT) at different temperatures.*

Table 1. *Langmuir and Freundlich constants for adsorption of MG dye on the two surfaces (PPACT, DPACT) at different temperatures*

T(K)	**Langmuir**						**Freundlich**					
	Surface											
	PPACT			**DPACT**			**PPACT**			**DPACT**		
	R^2	**k_L L/mg)**	**q_{max} mg/g**	**R^2**	**k_L L/mg**	**q_{max} mg/g**	**R^2**	**k_f mg/g**	**n**	**R^2**	**k_f mg/g**	**n**
293	0.9954	0.1661	6.9735	0.9977	0.2559	8.5543	0.99	48.6766	1.8928	0.9895	52.8839	1.7943
298	0.9943	0.2004	7.6394	0.997	0.3599	9.5238	0.9862	39.7575	2.1905	0.9822	36.0137	2.3618
303	0.9959	0.2305	8.1037	0.9926	0.2697	8.4817	0.988	35.4846	2.4090	0.9738	30.9787	2.7255
308	0.9967	0.2567	8.5034	0.9956	0.3466	9.2764	0.9886	32.7695	2.6021	0.9795	27.0882	3.1918

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
- **Author contributions:** The authors declare that they have equal right on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

[1] Koop, S. H., & van Leeuwen, C. J. (2017). The challenges of water, waste and climate change in cities. *Environment, Development and Sustainability*. 19(2);385-418. https://doi.org/10.1007/s10668-016-9760-4

[2] Rai, P., Gautam, R. K., Banerjee, S., Rawat, V., & Chattopadhyaya, M. C. (2015). Synthesis and characterization of a novel SnFe2O4@ activated carbon magnetic nanocomposite and its effectiveness in the removal of crystal violet from aqueous solution. *Journal of Environmental Chemical Engineering*. 3(4);2281-2291. https://doi.org/10.1016/j.jece.2015.08.002

[3] Bashir, I., Lone, F. A., Bhat, R. A., Mir, S. A., Dar, Z. A., & Dar, S. A. (2020). Concerns and threats of contamination on aquatic ecosystems. *Bioremediation and Biotechnology: Sustainable Approaches to Pollution Degradation*. 1-26. https://doi.org/10.1007/978-3-030-35691-0_1

[4] Hajira Tahir, H. T., Muhammad Sultan, M. S., & Qazi Jahanzeb, Q. J. (2009). Remediation of azo dyes by using household used black tea as an adsorbent. *African Journal of Biotechnology*. 8(15);3584-3589.

[5] Karthika, M., & Vasuki, M. (2017). Removal of artificial dye solution of brilliant green over a low-cost physically activated carbon prepared from coconut Shell by adsorptive technique. *Modern Chemistry and Applications*. 5(4);1000234-1000237. https://doi.org/10.4172/2329-6798.1000234

[6] Al-Badaii, F., Jansar, K. M., Ab Jalil, N. A., & Halim, A. A. (2024). Sustainable Boron Removal from Aqueous Solutions Using Pomegranate Peel Adsorbents: A Comprehensive Study on Isotherms, Kinetics, and Thermodynamics. *Desalination and Water Treatment*. 100045. https://doi.org/10.5004/dwt.2024.100045

[7] Tolkou, A. K., Maroulas, K. N., Theologis, D., Katsoyiannis, I. A., & Kyzas, G. Z. (2024). Comparison of Modified Peels: Natural Peels or Peels-Based Activated Carbons for the Removal of Several Pollutants Found in Wastewaters. *C*. 10(1);22. https://doi.org/10.3390/c10010022

[8] Al-Saidi, S. M. K., Al-Kharousi, Z. S. N., Rahman, M. S., Sivakumar, N., Suleria, H. A. R., Ashokkumar, M., ... & Al-Habsi, N. (2024). Thermal and structural characteristics of date-pits as digested by Trichoderma reesei. *Heliyon*. 10(6);e25795. https://doi.org/10.1016/j.heliyon.2024.e25795

[9] Al-Zahrani, F. A., Al-Shehri, B. M., El-Shishtawy, R. M., Awwad, N. S., Khan, K. A., Sayed, M. A., & Siddeeg, S. M. (2022). Characterization of Date Seed Powder Derived Porous Graphene Oxide and Its Application as an Environmental Functional Material to Remove Dye from Aqueous Solutions. *Materials*. 15(22);8136. https://doi.org/10.3390/ma15228136

[10] Sahib, S. & Abbas, A.M. (2017). Modifying and characterizing Iraqi bauxite clay and using it as an adsorbent surface for methyl green dye from its aqueous solutions. M.Sc thesis in Chemistry, College of Education for Pure Sciences / Ibn Al-Haytham, page 36.

[11] Sanati, M., Khalaji, A. D., Mokhtari, A., & Keyvanfard, M. (2021). Fast removal of methyl green from aqueous solution by adsorption onto new modified chitosan Schiff base. *Progress in Chemical and Biochemical Research*. 4(3);319-330. https://doi.org/10.22034/pcbr.2021.277905.1182

[12] Romer, I. C. P. P., Santana, I. V. P., Bengoechea, R. M. R., & Hernández, M. M. P. (2022). Coconut Shell Charcoal Adsorption to Remove Methyl Orange in Aqueous Solutions. In Sorption-From Fundamentals to Applications. *IntechOpen*. https://doi.org/10.5772/intechopen.96004

[13] Bahrami, M., Amiri, M. J., Rajabi, S., & Mahmoudi, M. (2024). The removal of methylene blue from aqueous solutions by polyethylene microplastics: Modeling batch adsorption using random forest regression. *Alexandria Engineering Journal*. 95;101-113. https://doi.org/10.1016/j.aej.2023.12.054

[14] Edet, U. A., & Ifelebuegu, A. O. (2020). Kinetics, isotherms, and thermodynamic modeling of the adsorption of phosphates from model wastewater using recycled brick waste. *Processes*. 8(6);665. https://doi.org/10.3390/pr8060665

[15] Muinde, V. M., Onyari, J. M., Wamalwa, B., Wabomba, J., & Nthumbi, R. M. (2017). Adsorption of malachite green from aqueous solutions onto rice husks: kinetic and equilibrium studies. *Journal of Environmental Protection*. 8(03);215-237. https://doi.org/10.4236/jep.2017.83017

[16] Faraj, A.R. & Abbas, A.M. (2020). Preparation and activation of biochar from the husks of Brosseau millet grains and its use for adsorption of Congo

Red dye. M.Sc thesis in Chemistry, College of Education for Pure Sciences / Ibn AlHaytham, pages 63-66.
[17] Elsherif, K. M., El-Dali, A., Alkarewi, A. A., Ewlad-Ahmed, A. M., & Treban, A. (2021). Adsorption of crystal violet dye onto olive leaves powder: Equilibrium and kinetic studies. *Chemistry International*. 7(2);79-89. https://doi.org/10.5281/zenodo.4680198
[18] Ho, Y. S., Porter, J. F., & McKay, G. (2002). Equilibrium isotherm studies for the sorption of divalent metal ions onto peat: copper, nickel and lead single component systems. *Water, Air, and Soil Pollution*. 141;1-33. https://doi.org/10.1023/A:1021304828010
[19] Arias Arias, F., Guevara, M., Tene, T., Angamarca, P., Molina, R., Valarezo, A., ... & Caputi, L. S. (2020). The adsorption of methylene blue on ecofriendly reduced graphene oxide. *Nanomaterials*. 10(4);681. https://doi.org/10.3390/nano10040681