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ASSESSMENT OF NIGERIAN LAUMONTITE ZEOLITE IN THE ADSORPTION OF ACID RED 27 AND BRILLIANT GREEN DYE IN SYNTHETIC WASTEWATER

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ABSTRACT

This study dwell on the removal of color of two different dye types namely Acid Red-27 (AA27) and Brilliant Green (BG) in a simulated waste dye water. An adsorption process in which the parameters were optimized with response surface methodology was adopted. Numerical optimization was determined at optimum conditions for BG and AA27, respectively and was used in carrying out a batch equilibrium studies while studying the effect of contact time, initial concentration and adsorbent dosage. The outcome of the experimentation indicate that the adsorbent dosage of the dye solution had a significant impact on adsorption. The result also showed that Freundlich isotherm fit the isotherm model for AA27, and Langmuir isotherm fit that of BG. The overall experimental data indicate a maximum removal of 96.24 % and 83.10 % was found for Brilliant Green and Acid Red 27 respectively while the maximum dye adsorption capacity of BG and AA27 was obtained at 68.02 and 3.43 mg/g, respectively. Activated Nigerian Laumontite zeolite has capability for adsorption and hence can be used for effective removal of dyes from wastewater.

Keywords: *Laumontite zeolite; Brilliant green dye; Acid red 27; Adsorption; Laumontite*

1. INTRODUCTION

The production of numerous pollutants due to industrialization and modernization has negatively impacted the environment (Bushra *et al.,* 2021). The use of water by many different process industries and its attendant effects through discharges pose an enormous challenge environmentally. Brilliant green is currently used in industry worldwide for a variety of tasks, including dying paper, leather, wool, and silk. Veterinary care, dermatological products, biological stains. Acid red 27 is useful as a food dye . It is also used in cosmetics, natural and synthetic fibers, leather, paper, and phenol-formaldehyde resin. This usefulness in the mentioned processes entails they are present in the wastewater released by several process industries, including textile industry (Zafar *et al.,* 2020). The level of Water pollution beyond the threshold limit is directly related to the general effects such as gastrointestinal tract which can lead to other secondary effect including nausea, vomiting, and diarrhea, and even coughing and shortness of breath.

There are several technologies available that are used for the removal of organic contaminants. These include oxidation method (Pathania *et al.,* 2016), treatment using biotic processes (Santos and Boaventura, 2015), the use of membrane process [Lau and Ismail, 2009], coagulation/flocculation, and adsorption (Wu *et al.,* 2017). Adsorption processes are the most widely used treatment techniques for eliminating organic contaminants (Mahmoud *et al.,* 2020) because of its simplicity and effectiveness as well as economical advantage over other processes (Albadarin *et al.,* 2017). There are several adsorbents well known to possess good adsorption properties such as activated carbon, fly ash, clay minerals and zeolites. Zeolite is an aluminosilicate material (both synthetic and natural) with a polyhedral three-dimensional structure made up of $[SiO]^{4-}$ and

$[AIO]^{5-}$ complexes. These compounds have a specific chemistry and qualities that make it possible for them to adsorb various environmental pollutants (Alakhras *et al.,* 2020). Laumontite natural zeolites which have been studied extensively used as adsorbents was recently discovered in part of Nigeria and they are known to have good surface area, porous structure, and ion-exchange capabilities. This study is therefore aim to assess the efficacy of this new natural zeolite (NZ) sourced from Adamawa , Nigeria as an adsorbent for wastewater treatment by removing Acid Red 27 and Brilliant Green dye.

2. MATERIALS AND METHODS

2.1. Materials

Natural laumontite zeolite (NLZ) was sourced from Ganki, Fufore LGA in Adamawa State, Nigeria. All chemical used in this work were of analytical grade.

2.2. Purification and Modification of the Adsorbent material

First, 100 g of NLZ was crushed and sieved using 300 μm mesh, this was then followed by washing of the sieved NLZ with large quantity of deionized water to remove impurities and finally dried in oven for 6 h at 110 °C. The activation of the natural zeolite was carried with the aid of NaCl. The activation process to convert LAU-NZ in Na-form was prepared according to previous procedures described in the literature (Hasan, 2023). 28.89 g of NLZ was added to 1M NaCl solution which was stirred for 20 h at 50 rpm. The material was decanted, and was washed

four times with deionized water to remove excess sodium chloride and finally dried in the oven at 110 °C for 9 h.

2.3. Characterization of natural Laumontite zeolite

The analysis of NLZ and activated NLZ before and after the adsorption of brilliant green and acid red 27 was carried out using by Fourier transform infrared spectroscopy (FT-IR) for it functional groups, the microstructure/morphology was performed by a scanning electron microscope (SEM), the X-ray fluorescence was used to determine a material's oxide composition, and the crystallographic structural properties was determined by X-ray powder diffraction (XRD) (Model: EMPYREAN from Netherlands) in the 2θ range of 5-70.

2.4 Empirical optimization design

Box-Behnken (BBD) was employed to evaluate the impact of process factors on the removal efficiency of BG AND AA27 on NLZ. The selected variables were initial concentration (40 – 200 mg/l), Contact time (30 – 240 min) and adsorbate dosage (0.05 -0.3 g). 17 experiment runs were generated using Design Expert software (Ver.13.0).

Table 1 Independent factors and their chosen level of the experimental design

Name	Symbol	Low	High
Contact time (min)	A	30	240
Adsorbent dosage (g)	B	0.05	0.3
Intial concentration (mg/l)	C	40	200

Table 2 Full BBD Experimental Design Table

	Factor 1	**Factor 2**	**Factor 3**
Runs	A: Initial concentration (mg/l)	B: Contact time (min)	C: Adsorbent dosage (g)
1	40	30	0.175
2	120	240	0.05
3	40	135	0.05
4	120	135	0.175
5	40	135	0.3
6	200	30	0.175
7	120	30	0.3
8	120	135	0.175
9	120	135	0.175
10	120	135	0.175
11	200	135	0.3
12	120	30	0.05
13	40	240	0.175
14	200	135	0.05
15	120	135	0.175
16	200	240	0.175
17	120	240	0.3

Diagnostic plots and analysis of Variance (ANOVA) were utilized in the statistical study to evaluate the statistical significance of the regression coefficient of the suggested models and optimum conditions for the adsorption process.

2.5 Numerical Optimization

Numerical optimizations were performed using the 'optimization' selection on Design Expert v13.0. Maximizing removal efficiency within the parameters and keeping all process variables within them were the objectives of the numerical optimization, subject to a few carefully considered constraints (Bader *et al.*, 2018; Cui *et al.*, 2019).

2.6 Adsorption experiment

The adsorption of BG and AA27 on activated NLZ was carried out by batch method. This was done by shaking 50 ml of a known initial dye concentration with known amount the adsorbent NLZ in 250 mL and the solution was stirred at 210 rpm according to the experimental variables obtained from the design factors as given by the BBD experimental design. The solution of the adsorbent and adsorbate were separated using a filter paper and the filtrate was tested for the absorbance using a UV-visible spectrophotometer. All samples were filtered before the residual acid red 27 and brilliant green quantity were quantified using UV spectroscopy at 519.50 nm and 624.50 nm respectively.

The amount of dye adsorbed at equilibrium q_e (mg/g) was calculated at equilibrium condition using Eq. (1):

$$Q_e = \frac{C_0 - C_e}{w} * V \quad (1)$$

Where C_0 and C_t are the initial concentration and final concentration of Acid red 27 and Brillant green in the solution (mg/L); V is the volume of Acid red 27 (L); W is the weight of adsorbent (g).

The removal efficiency was calculated using equation 2:

$$R = \frac{C_0 - C_t}{C_0} \times 100\% \quad (2)$$

Where C_0 and C_t are the initial concentration and final concentration of Acid red 27 and Brillant green in the solution (mg/L).

2.6.1 Adsorption isotherms

The experimental data was analyzed using Langmuir and Freundlich isotherms, and the molecular distribution of adsorbate on the adsorbent surface was done for [Jahan et al., 2023] acid red 27 and brilliant green (Zafar *et al.*, 2020; Mansour *et al.*, 2020) for their adsorption characteristic.

Equation 3 represents the linear Langmuir model:

$$\frac{c_e}{q_e} = \frac{c_e}{q_{max}} + \frac{1}{q\,max\,k_L} \quad (3)$$

where q_e is the equilibrium adsorption, and q_{max} is the maximum adsorption capacity (mg/g), C_e is the

equilibrium concentration (mg/L) related, and k_L is the Langmuir isotherm constant (L/mg) related to the affinity of the binding sites to the adsorbate

Equation 4 represents the linear Freundlich model:

$$\text{Log } q_e = \log K_f + \frac{1}{n} \log C_e \quad (4)$$

The parameter in equation 3 are describe as follows, q_e is the equilibrium adsorption (mg/g), C_e is the equilibrium concentration (mg/L), k_F is the Freundlich isotherm constant (mg/g), and 1/n is dimensionless representing the heterogeneity of the adsorbent sites and also indicates the affinity between adsorbate and adsorbent.

3. RESULTS AND DISCUSSION

3.1. Zeolite Analysis

The first five 2-theta peaks in the diffractogram clearly match the pattern of typical peaks for NLZ as described in the literature, which displays all of the peaks that are characteristic for Laumontite (Treacy and Higgins, 2007). The X-ray diffractograms of NLZ in (Fig.2a) show that the main diffraction peaks at 2θ angles, major peak values for the first five 2-theta of the samples are seen at around 7.5°, 12.5°, 25.0°, and 28.5° corresponding to hkl plains of (110), (200), (-112), and (330), respectively. The SEM images of NLZ as shown in fig 2b micrograph displayed a large plate-like structure, suggesting that the silica and alumina are sliding over one another, and the SEM micrograph revealed a uniform particle size of the sample with a regular shape when compared with literature (Hosaka *et al.*, 1995).

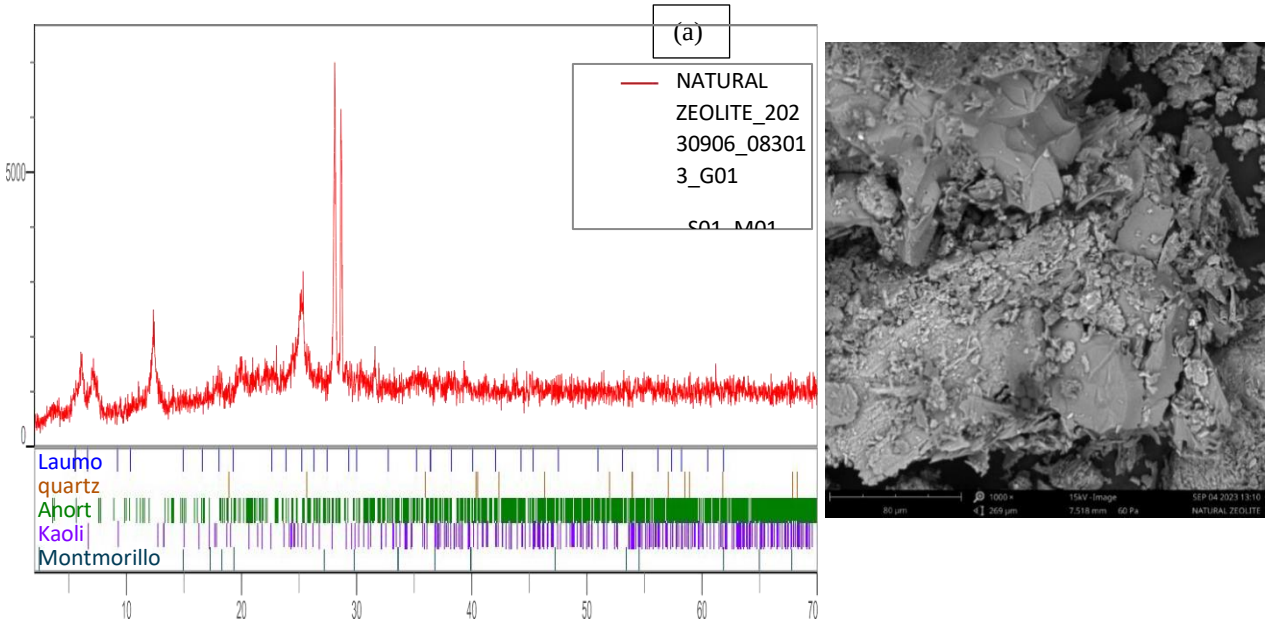


Figure 2. (a) X-ray diffractogram of LAU-NZ and (b) SEM image of LAU-NZ

The XRF analysis result as shown in Table 3 was used to determine the oxides and elemental compositions of the NLZ. The result as shown in table 3 present results from the X-ray Fluorescence analysis clearly indicate the preponderance of various oxide composition of the natural material

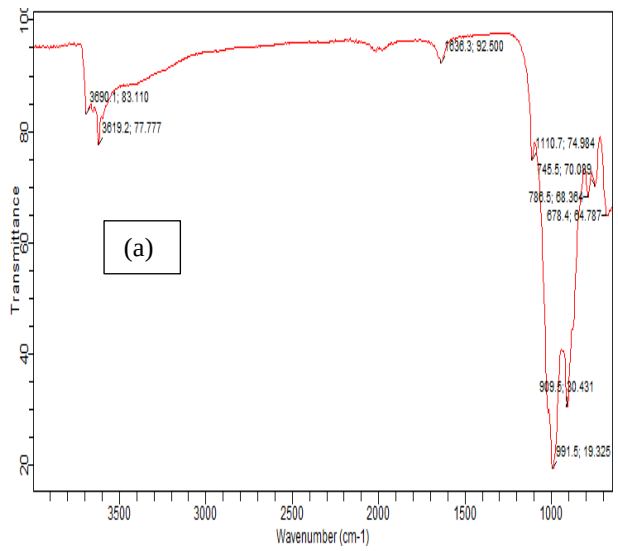
Table 3 shows the oxides, elements, and percentage weight concentrations of LAU-NZ.

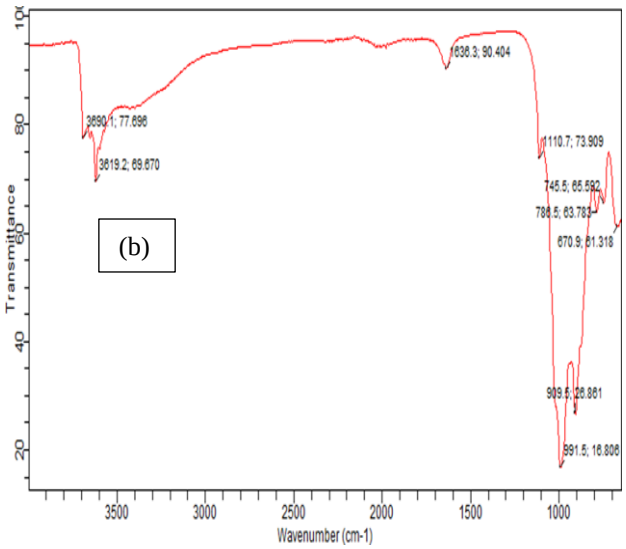
OXIDES	CONCENTRATION WT.%	ELEMENT	CONCENTRATION WT.%
SiO_2	46.524	O	45.545
V_2O_5	0.068	Al	11.194
Cr_2O_3	0.150	Si	21.747
MnO	0.135	S	2.036
Fe_2O_3	15.170	Cl	0.487

OXIDES	CONCENTRATION WT.%	ELEMENT	CONCENTRATION WT.%
$Co_3 O_4$	0.051	K	1.348
NiO	0.041	Ca	6.021
CuO	0.040	Ti	0.538
Nb_2O_3	0.015	V	0.038
MoO_3	0.023	Cr	0.103
SO_3	5.085	Mn	0.104
CaO	8.424	Fe	0.611
K_2O	1.624	Co	0.037
BaO	0.073	Ni	0.032
Al_2O_3	21.150	Cu	0.032
Ta_2O_5	0.004	Zn	0.015
TiO_5	0.897	Zr	0.016
ZnO	0.019	Nb	0.012
ZrO_2	0.022	Ba	0.066

The sample has Si/Al ratio greater than one (1.942 as shown in Table 3). Given that the minimal Si/Al ratio should be 1 and 1.3 – 3.3. the outcome appears to be in line with Breck DW and Loewenstein's rule for aluminum in four-fold coordination respectively (Soscún *et al.*, 2001).

FTIR spectra of activated NLZ, adsorbed AA27, and adsorbed BG in Fig.3 shows the band (4000 - 2500 cm^{-1}) is the stretching vibrations of Si-OH and Si-OH-Al, the band at (2500 - 2000 cm^{-1}) are attributed to the bending vibrations of water molecules H-O-H, (2000 - 1500 cm^{-1}) is due to asymmetric stretching vibrations of (C=O), and (1500 -400 cm^{-1}) asymmetric and symmetric stretching vibration of internal (Kumar, 2019). In Fig.3c, distinct absorption peaks at (1192.7 -1,786.5 cm^{-1}) are attributed to the asymmetric stretching vibration of internal T-O(T) bonds and symmetric stretching vibration of internal T-O(T) bonds (Hasan, 2023) and Fig.3b, The minimal shift of the T-O bond and C=O bands after loading the dye is due to the strong intensities surface complexation of the dye substance with these functional groups.





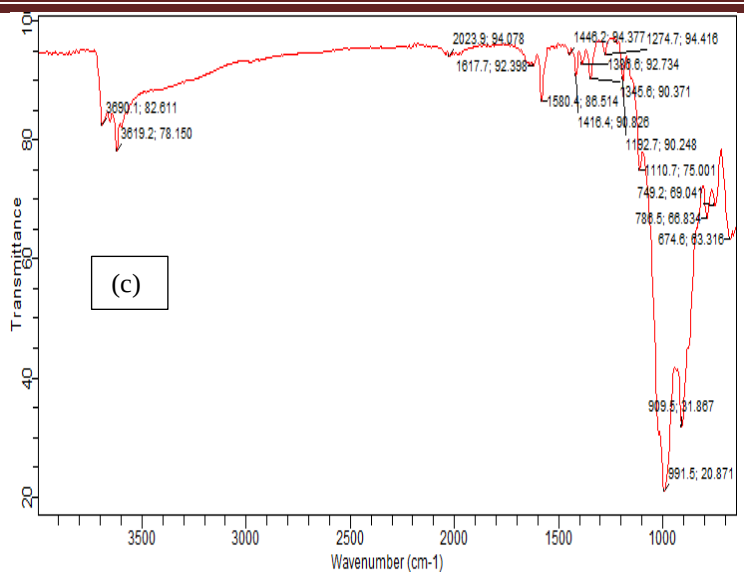


Figure 3. FTIR analysis on (a)Activated zeolite, (b)Adsorbed AA 27, and (c)Adsorbed BG

3.2 ANOVA and Diagnostic model

The results of the ANOVA demonstrated that the relationships between each response and the important factors were accurately reflected by the equations. According to the model, A, B, C, AB^2, AC^2, BC^2, A^2, B^2, and C^2 were significant model terms. Additionally, lack of fit became critical because of certain systematic fluctuations that this model was unable to account for. Equations (5) and (6) of the software's model showed how the independent parameters taken into account and % removal of BG and AA27 are related.

$$\% \text{ Removal} = +91.5231 + 4.51816\,A - 0.159446\,B + 0.478342\,C + 0.440712\,AB - 0.167962\,AC + 0.795563\,BC - 3.72207A^2 - 0.12296\,B^2 + 0.347415\,C^2 \quad (5)$$

$$\% \text{ Removal} = +99.40 + 0.9539\,A - 0.0380\,B + 0.1481\,C - 0.2492\,AB - 0.6224\,AC + 0.4053\,BC - 0.9194\,A^2 + 0.0669\,B^2 - 0.4996\,C^2 \quad (6)$$

An increase or decrease in response resulting from independent and interaction factors is indicated by a positive or negative sign in the equation. The adsorption yield is greatly influenced by all three of the parameters, according to the ANOVA analysis. In contrast, for both dyes, the adsorption yield is positively impacted by the dye concentration and adsorbate dosage in solution; the activated zeolite contact time has a negative impact according to the correlation coefficients

The preparation conditions and experimental results for the studied responses are shown in Table 4. Values of adsorption capacities varied between 9.50 and 184.95 mg/g for AA27 and between 6.52 and 198.78 mg/g for BG. The highest values of 184.95 and 198.78 mg/g were obtained for the activated zeolite of 0.05 g.

Table 4: Box-Behnken design actual values and experimental results responses

Run	Actual values			Qe (mg/g)		%Removal	
	Contact time (min)	Adsorbate dosage (g)	Dye Concentration (mg/g)	AA27	BG	AA27	BG
1	30	0.175	40	9.50	11.12	83.14	97.31
2	240	0.05	120	109.42	117.99	91.18	98.33
3	135	0.05	40	33.65	38.50	84.13	96.24
4	135	0.175	120	31.33	34.04	91.38	99.30
5	135	0.3	40	5.47	6.52	81.10	97.82
6	30	0.175	200	52.75	56.98	92.32	99.72
7	30	0.3	120	18.14	19.76	90.72	98.81

Run	Actual values			Qe (mg/g)		%Removal	
	Contact time (min)	Adsorbate dosage (g)	Dye Concentration (mg/g)	AA27	BG	AA27	BG
8	135	0.175	120	31.52	34.10	91.92	99.47
9	135	0.175	120	31.10	34.12	90.70	99.51
10	135	0.175	120	31.30	34.08	91.29	99.39
11	135	0.3	200	30.70	33.16	92.11	99.48
12	30	0.05	120	110.04	119.23	92.70	99.36
13	240	0.175	40	9.64	11.19	84.31	97.88
14	135	0.05	200	184.95	198.78	92.48	99.39
15	135	0.175	120	31.66	34.06	92.33	99.35
16	240	0.175	200	53.04	56.74	92.81	99.30
17	240	0.3	120	18.68	19.88	93.39	99.39

Table 5: Analysis of variance for AA27 model

Source	Sum of Squares	df	Mean Square	F-value	p- value	
Model	227.60	9	25.29	52.20	< 0.0001	significant
A-Initial concentration	163.31	1	163.31	337.06	< 0.0001	
B-Adsorbate dosage	0.2034	1	0.2034	0.4198	0.5377	
C-Contact time	1.83	1	1.83	3.78	0.0930	
AB	0.7769	1	0.7769	1.60	0.2459	
AC	0.1128	1	0.1128	0.2329	0.6441	
BC	2.53	1	2.53	5.23	0.0561	
A^2	58.33	1	58.33	120.39	< 0.0001	
B^2	0.0637	1	0.0637	0.1314	0.7277	
C^2	0.5082	1	0.5082	1.05	0.3398	
Residual	3.39	7	0.4845			
Lack of Fit	1.83	3	0.6095	1.56	0.3305	not significant
Pure Error	1.56	4	0.3908			
Cor Total	230.99	16				

Table 6: Analysis of variance for BG model

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	14.75	9	1.64	148.95	< 0.0001	significant
A-Initial concentration	7.28	1	7.28	661.60	< 0.0001	
B-Contact time	0.0115	1	0.0115	1.05	0.3401	
C-Adsorbate dosage	0.1755	1	0.1755	15.95	0.0052	
AB	0.2484	1	0.2484	22.57	0.0021	
AC	1.55	1	1.55	140.82	< 0.0001	
BC	0.6572	1	0.6572	59.73	0.0001	
A^2	3.56	1	3.56	323.48	< 0.0001	
B^2	0.0189	1	0.0189	1.71	0.2319	
C^2	1.05	1	1.05	95.54	< 0.0001	

Residual	0.0770	7	0.0110			
Lack of Fit	0.0467	3	0.0156	2.06	0.2488	not significant
Pure Error	0.0303	4	0.0076			
Cor Total	14.83	16				

Fig. 4, provides statistical actual and predicted values to test the significant effects of regression coefficients for the proposed models. In Fig. 4a, which showed the distribution of BG adsorption data points close to the straight line, while AA27 data in Fig. 4b deviated from the straight line. Consequently, there was a reasonable agreement between the "R^2" and the "R^2_{adj}". Additionally, "R^2" was higher than "R^2_{adj}". It is evident that over 90% of these reactions are accurately anticipated by these models, suggesting that the terms taken into account in the suggested models were important enough to produce predictions that could be accepted (Tounsadi, *et al.*, 2016).

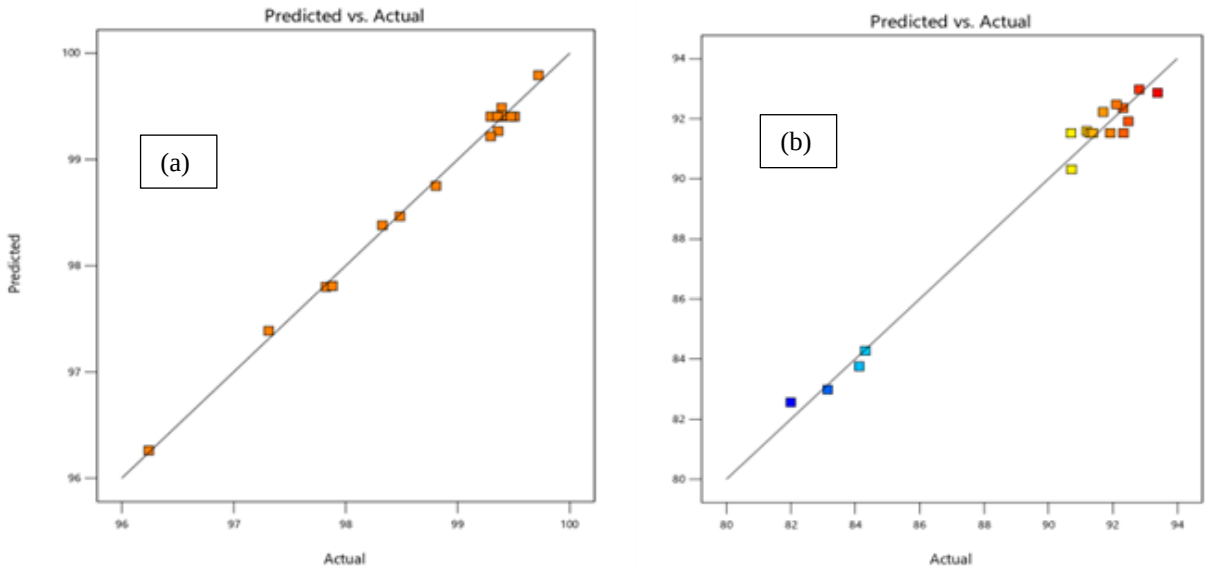


Figure 4: Predicted values vs. actual values for (a) BG, and (b) AA27

3.3 Numerical Optimization

Maximizing removal efficiency within the parameters and keeping all process variables within them were the objectives of the numerical optimization, subject to a few carefully considered constraints (Bader et al., 2018; Cui et al., 2019). These constraints are presented in Table 7 and 8 for the dyes below.

Table 7: Factor and response constraints on the numerical optimization for BG

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
A: Initial concentration	is in range	40	200	1	1	3
B: Contact time	is in range	30	240	1	1	3
C: Adsorbate dosage	is in range	0.05	0.3	1	1	3
Removal	maximize	96.2417	99.721	1	1	3

Table 8: Factor and response constraints on the numerical optimization for AA27

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
A: Initial concentration	is in range	40	200	1	1	3
B: Adsorbate dosage	is in range	0.05	0.3	1	1	3
C: Contact time	is in range	30	240	1	1	3
% Removal	maximize	81.9975	93.387	1	1	3

Table 6 and 7, shows the maximum removal efficiencies were observed to be 96.24% and 81.10% for BG and AA27 dyes, respectively. The optimum condition for BG is at initial concentration of 190.428 mg/l, adsorbent dosage of 0.159 g, and contact time of 69 min and that of AA27 at initial concentration of 166.649 mg/l, adsorbent dosage of 0.274 g, and contact time of 210 min The desirability values of these parameters which is a show of the ideal and desired values were observed to be 1.000 (unity) for the two dyes. The result indicate the acceptance of the predicted adsorption removal efficiencies and the applicationn of the model for the dyes removals .

3.4 Batch adsorption experiment

3.4.1. Effect of initial concentration

A plot of removal efficiency of the BG dye is shown in Figure. 5a, while keeping other factors constant (adsorbent dosage = 0.159 g, contact time = 69 min). It can be observed that the number of active sites on the surface of the adsorbent is more available at low initial dye concentrations than it is at high initial dye concentrations. The removal efficiency of BG rises proportionally with the initial concentration (Alene *et al.*, 2020). In Fig. 5b, while keeping other factors constant (adsorbent dosage = 0.274 g, contact time = 210 min), the removal efficiency of AA27 increases inversely with the initial concentration. The number of effective adsorption sites on the adsorbents exceeds the number of competent AMD molecules at lower starting concentrations. Because of this, a greater percentage of AA 27 molecules exhibit increased adsorption effectiveness when they are bound to the adsorbent surface (Rahaman *et al.*, 2022). This show that these process favors at higher concentration.

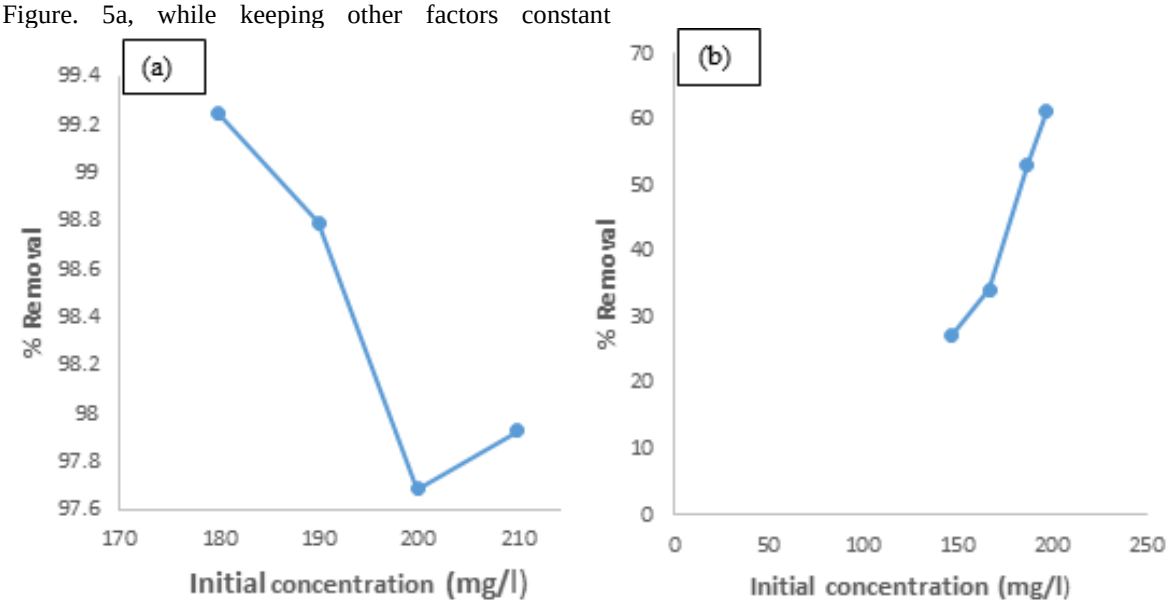


Figure 1: Effect of initial concentration on adsorption of (a)BG dye, and (b) AA27 onto AZ

3.4.2 Effect of adsorbent dosage

The plot of removal efficiency against adsorbent dosage as presented in Figure. 6 shows that adsorbent dosage is one of the independent variables that can alter the dye. removal efficiency. The study was at constant conditions of initial concentration = 190 mg/l and contact time=69 min for BG and initial concentration = 167 mg/l and contact time= 210 min for AA27, respectively. Between the two dyes, the removal efficiency of BG is greater than that of AA27 as shown in the plot with changes in the activated zeolite dosage which is due to the amount of more adsorbent active sites and more adsorbent specific surface area become available, leading to an increase in the removal percentage of both dyes onto activated zeolite (AZ) (Alene *et al.*, 2020).

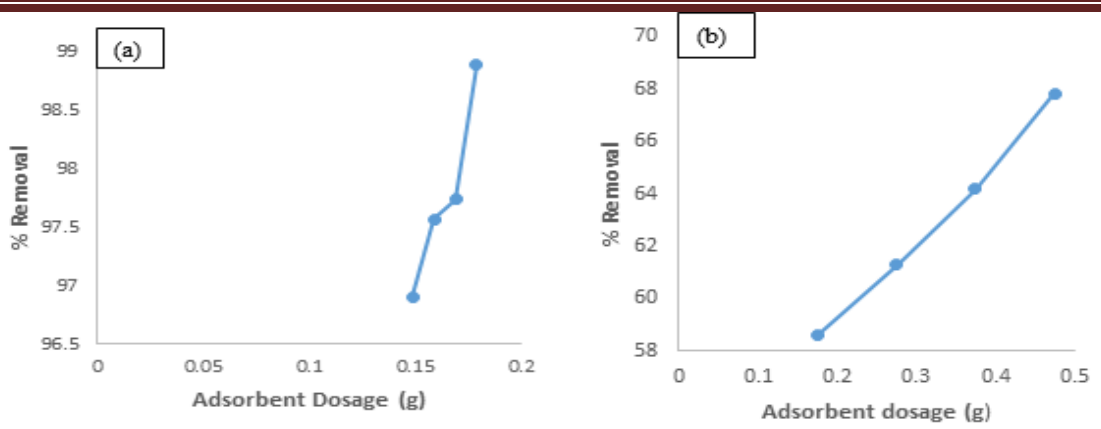


Figure 2: Effect of adsorbent dosage on adsorption of (a)BG dye, and (b)AA27 onto AZ

3.4.3 Effect of contact time

The effect of removal efficiency on contact time was studied at constant conditions of (Adsorbent dosage = 0.159 g and initial concentration = 190 mg/L) for BG and that of AA27 (Adsorbent dosage = 0.274 g and initial concentration = 167 mg/L) efficiencies of both dyes were affected by contact time as observed from Fig. 7. From the plot, it was noticed that the removal efficiency for the dyes increased with longer time of contact between the activated LAU-NZ and adsorbate. In Fig. 7a, It is evident that the dye's initial removal efficiency increased during the first 59 minutes, and that this was followed by a slow removal rate until the 89-minute mark. However, as equilibrium takes longer to reach, the number of surface sites that remain will decrease and it will become more difficult to occupy these ions (Samaka, 2021) whereas, in Fig. 7b, it was observed that there was a steep increase in the amount of dye adsorbed from 210 - 230 minutes which follows by a steady increase. Due to the unavailability of the active adsorption sites on the adsorbent surface, the adsorption effectiveness falls as the contact time increases (Munagapati *et al.*, 2021).

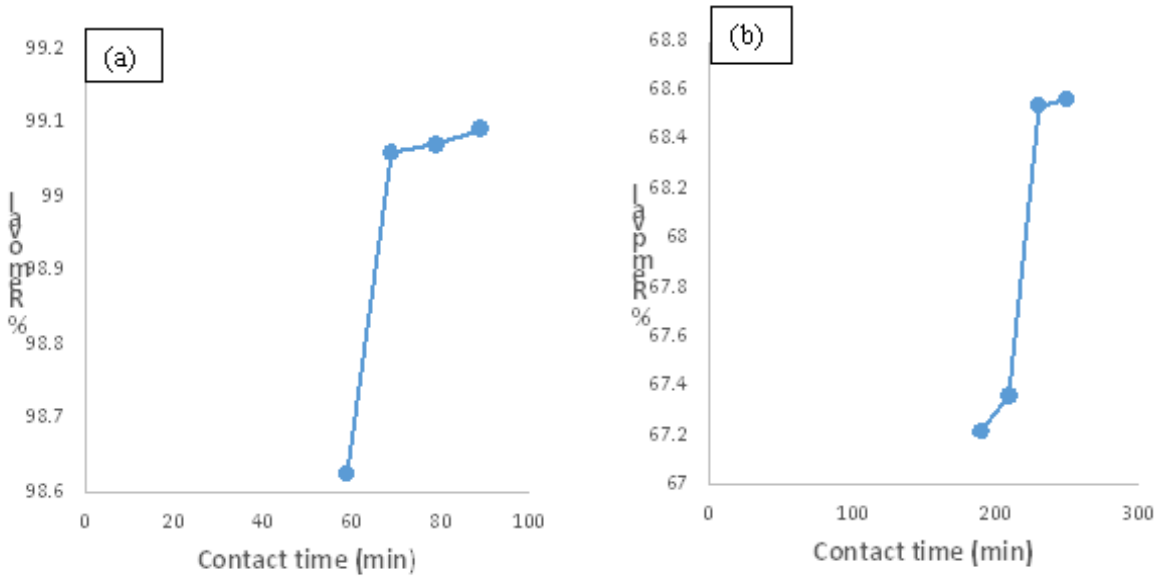


Figure.3: Effect of contact time on adsorption of (a)BG dye, and (b) AA27 onto AZ

3.5 Adsorption isotherm

Fig.8a and 8b represented the Langmuir isotherm plots of BG and AA27 respectively. Table 9 shows the adsorption parameters in the adsorption on activated LAU-NZ**,** along with the correlation coefficient R^2 of nearly 1. In Fig 8, the maximum adsorption capacities (q_{max}) of the AZ were

found to be 68.02 mg/g, and 3.43 mg/g for BG and AA27.Therfore, the adsorption of BG on activated LAU-NZ was best described using this model which showed single monolayer adsorption of BG on the surface of activated LAU-NZ as compared to AA27.

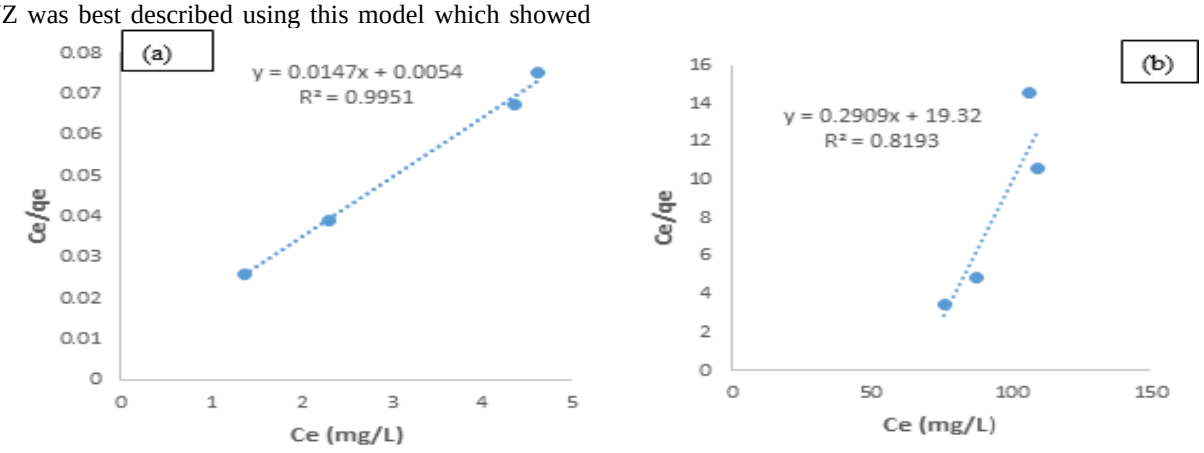


Figure4: Langmuir isotherm plots of (a) BG and (b) AA27 27 onto AZ

The Freundlich isotherm shows the plot of log C_e vs. log q_e as shown in Fig. 9a for BG and Fig.9b for AA27, respectively and both the values of 1/n and K_f can be calculated from the slope and intercept. It is considered good adsorption if the n value is (0> n <1) (Munagapati *et al.*, 2021). In this study, the n value obtained from Freundlich model for BG and AA 27 was found to be 10.47 and 0.37, respectively, indicating the adsorption of BG is unfavorable and that of AA27 is favorable. This indicate that this isotherm is a better representation model for Acid red 27 dye.

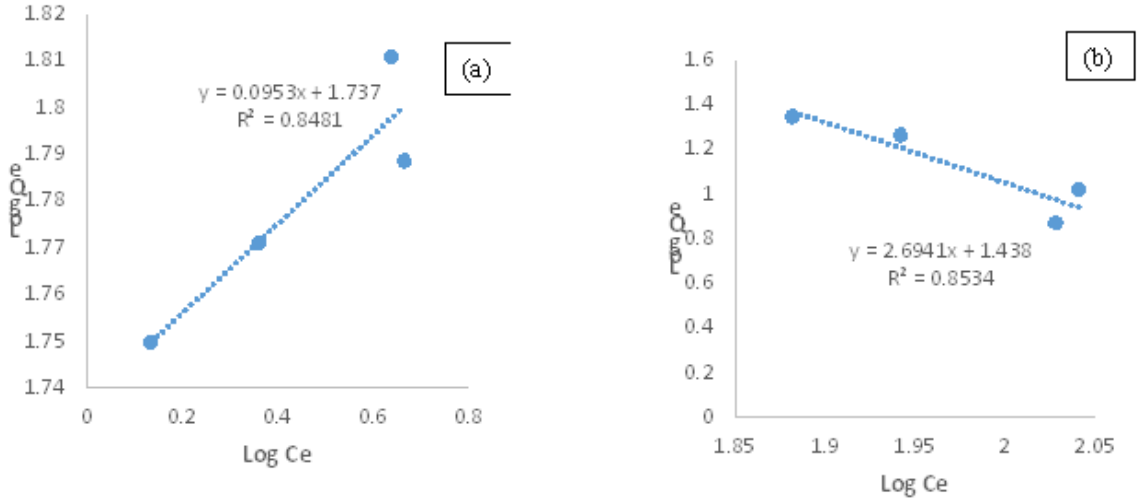


Figure 5: Freundlich isotherm plots of (a) BG, and (b) AA27 onto AZ

Table 9: The adsorption isotherms parameters for Langmuir and Freundlich model

Adsorption parameters	Brilliant Green	Acid Red 27
Langmuir isotherm		
K_L (L/mg)	2.72	5.62
q_{max} (mg/g)	68.02	3.43
R^2	0.9951	0.8193
R_L	0.0017	0.0015
Freundlich isotherm		
K_f (mg/g)	54.58	27.42
1/n	0.0953	2.6941
R^2	0.8421	0.8534

4. CONCLUSION

The removal efficiency and maximum adsorption capacities of BG and AA27 were 68.02 and 3.43 mg/g respectively with optimum removal efficacy of 96.24% and 83.14%. Characterization on the LAU-NZ by SEM, XRD and XRF. FTIR analysis was done on the activated and after adsorption. The optimal experimental conditions for the removal of the maximum dye were determined on contact time, initial concentration, and adsorbent dosage. From ANOVA, it showed that the BBD model was statically significant. It was observed that the independent variables were all significant which implies that all factors variable studied had specific impact on its removal efficiency. Numerical optimization (unity) was found to be the desirability values of these parameters, which represent the ideal and desired values. Isotherms models of Langmuir and Freundlich were applied to study adsorption of BG and AA27 on activated natural zeolite. The adsorption behavior of Langmuir was best represented (R^2 = 0.9951) for BG with maximum adsorption capacity of 68.02 mg/L and AA27 is described by Freundlich isotherm (R^2 = 0.8534). The current investigation reveals that the activated Laumontite zeolite that has been made using inexpensive method was effectively used in the removal Acid Red 27 and Brilliant Green, from simulated dye wastewater that and the results prove very successful.

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