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A Novel Treatment of Textile Wastewater for Safe and Environmental Friendliness Ecosystem using Activated Hamburger Seed Sheel

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Abstract:- Textile industries produce lot of undesirable biological or chemical substance, that are contaminated. These contaminates are in form of acidic or caustic dissolved solids, toxic compound, and different dyes. Some organic dyes are hazardous and have adverse effect on living organisms (Mohammed, 2014). Large percentage of the dye does not bind to the fabric during coloration, thus it is easily loss in wastewater stream. During dyeing process, some percentage of dyes are released into the environment, thus colourising the effluent highly colored and making it aesthetically unpleasant in different industrial applications and aquatic ecosystems (Ahmad et al., 2015; Aksu, 2005; Brillas, and Martínez-Huitle, 2015). Dyes are resistance to light, microbial attack, recalcitrant and toxic to water temperature, ejecting them into water bodies usually inhibit penetrations of sun lights essential for photochemical and biological activities by the aquatic life (Ertugay and Acar, 2017; Mittal et al., 2014). Therefore, adequate treatment of industrial wastewater containing dyes prior to discharge is advantageous, by effectively extractingdye color in order to protect the environment. Methylene blue was used as adsorbate and conventionally activated hamburger seed shell as adsorbent. The experiment was done using a simulation method due to inability to solely separate all other elements present in textile waste water. The Kinetics of the adsorption was matched into 4 Kinetic models the first order kinetic1 model, second order kinetic2 model, pseudo first and second order kinetics3,4 model respectively, it was then observed that the adsorption kinetic matched best to the psuedo second order kinetic4 model, which had high coefficient of correlation between the calculated and experimental adsorptive capacities. Langmuir and Freundlich isotherm models was used to analyse the data. Isotherm data matched the Freundlich model. Contact time, pH. dye concentration and absorption dosage were studied. The data were analyzed by calculating the adsorptive capacity and percentage removal at equilibrium. The result shows that contact time while the effect of initial concentration increases with decrease in percentageremoval, while the percentage removal increases with increase in adsorbent dosage,pH. The percentage removal of methylene blue increased with decrease in initial methylene blue concentration and increased with increase in contact time and dose of the adsorbent. This research is vital to management of agricultural waste, and its industrial application. It will empower researchers to focus on agricultural waste rather than disposing randomly. It is beneficial for environment protection, to carry out proper treatment of industrial wastewater containing dyes prior to dischargeby effectively extracting dye color.

I. INTRODUCTION

This project work critically examined "The Treatment of Methylene Blue (MB) dye textile wastewater usingHamburger Seed Shell. Activated Hamburger seed shell was used to adsorbed MB dye from the aqueous solution. Through the process of carbonization at a temperature of about 800^{0}C for 2 hours, followed by activation using conc. KOH 9m as activating agent at a temperature of 850^{0}C for 1hour, activated carbon was first prepared from the hamburger seed shell.

In the past decades, several researches have been carried out on how to efficiently remove dyes from industrial effluents using various methods such as; adsorption, advanced oxidation, and membrane separations (Ahmad et al., 2015; Yagup et al., 2014). Reports showed that these methods were effective and displayed varying degree of dye removal from the industrial wastewater (Kyzas et al., 2015; Yagub et al., 2015). However, amongst these methods, adsorption wasthe most effective with applications in some industries for the removal of recalcitrant pollutants from the effluents before discharge into water bodies (Kyzas et al., 2015). Recently, researchers are investigating the treatment of this dye-containing effluent using cost effective means through agricultural waste such as activated carbon. Researchers now focus on agricultural products becausethey are inexpensive, ecofriendly, and renewable (Alshabanat et al.,2013).

Industrial and agricultural waste rich in carbonaceous materials such as wood, coir,coconut shell, peat, rice husk, lignite, and coal from researchers have shown to have activated carbon (Aljeboree et al., 2017; Mullick et al., 2018). Research was carried out onthe comparative analysis of the performance of activated carbon produced from two

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industrial wastes namely rice husk and coconut shell activated with H_2PO_4 used for the adsorption of methylene blue from a synthesized industrial wastewater in a system. Conventional treatment methods were ineffective in the removal of color from dye-bearing effluents due to the difficulty in treatingsuch waste waters (Pragathiswaran et al ., 2016).

Wastewater containing dyes must be adequately treated before discgarging into water bodies (Gbekeloluwa et al.,2014). Physical, chemical and biological treatments are conventional methods for the treatment of colored wastewater (Mohammed et al .,2014). However, these technologies are not applicable due to issues including; high reagent or energy requirementsor generation of toxic sludge, and other waste products, incomplete dye removal, acquisition of expensive equipment and monitoring systems (Gbekeloluwa et al., 2014).

On an industrial scale, over the last few decades, adsorption has gained importance as a purification, separation and recovery process. Activated carbon (AC) is used widely as adsorbents in industry for environmental applications. Activated carbons are commercially the most common adsorbents used for the removal of organic and inorganic pollutants from air and water streams (Gottipati, 2012); they are carbons of highly microporous structure with both high internal surface area and porosity (Gottipati, 2012). Activated carbon can be made from any cheap material with a high carbon content and low inorganics (Bansal et. al., 1988). The high adsorption capacities of activated carbons are related to the properties such as surface area, pore volume and pore size distribution (PSD). AC characteristics depends on the type of raw material from which it is made and the method of activation. Due to the increasing demand of AC, new precursors should be made, for the preparation of AC which should be cost effective compared with the commercially available AC.

Physical activation and chemical activation are two basic processes for the preparation of AC. Physical activation involves carbonization of carbonaceous material followed by the activation of the resulting char at high temperatures (800 – 1100oC) in presence of oxidizing agents such as CO2 and steam (Gottipati, 2012). In chemical activation the precursor is mixed with a chemical agent and then pyrolyzed at low temperatures in absence of air by use of microwave. Chemical activation is better than the physical activation as it is done in a single step combining carbonization and activation,to yield better porous structure. Moreover, the added chemicals for activation can be easily recovered (Ahmadpour & Do, 1996). Activated carbon have great adsorption capacity towards a variety of solutes that why it is widely used (Zhang et. al., 2008). Activated carbon must either be disposed of as solid waste and replaced with fresh carbon or be regenerated, on reaching it undertake capacity (Nahm et. al., 2012). Due to relative high initial cost of activated carbon and the fact that disposal of spent adsorbents via landfills or incineration adds pollutants to the environment, carbon regeneration must be considered. The objectives of carbon regeneration are great adsorption capacity towards a variety of solutes, theselective removal of the adsorbates that have accumulated during the adsorption operation, and activity of the carbon with little damage on it (Vliet, 1991). Regeneration of activated carbon bring along considerable economic profit, economizes the natural resources and reduce the secondary pollution (Oin et. al., 2001). Some scientists in recent years, have focused on the research of the mechanism and technology of activated carbon regeneration (Liu, et. al., 2001).

The aim of this project is implementation of activated carbon from hamburger seed shell for the sole aim of adsorption of methylene blue.

➢ *The objectives of this Project are as follows:*

- *To prepare adsorbents from the precursor (hamburger seed shell)*
- *To investigate the characteristic of the activated hamburger seed shell(adsorbent)*
- *To apply the adsorbent in the adsorption of methylene blue dye*
- *To evaluate the percentage removal and adsorptive capacity of the adsorbent.*
- *To evaluate the kinetics, isotherm of the adsorption process.*

The rest of this paper is structured as follows, section two considers related works. Materialsand Methodology are presented in section three. The result and analysis are discussed in section four. Section five concludes the paper.

II. RELATED WORKS

Emad et. al. (2006) studied the removal of basic dye (Methylene Blue) from aqueous solution using bituminous coal-based activate carbon by Equilibrium adsorption isotherm. The results show the potential use of the adsorbent for the removal of Methylene Blue (MB) from aqueous solution with maximum adsorption capacity of 580 mg/g at equilibrium. The optimum pH which played a major part used for the removal of MB from the aqueous solution used was 11. The Redlich Peterson isotherm indicates from the high values of the correlation coefficients (r2 > 0.99). Tan et. al. (2007) studied oil palm fibre activated carbon using Equilibrium and kinetic studies on basic dye adsorption. Adsorption isothermof methylene blue on activated carbon was determined by batch tests. Thethree parameters (contact time, initial MB concentration, temperature) studied determined proportionally. Langmuir isotherm showed the equilibrium data, with maximum monolayer adsorption capacity of 277.78 mg/g at 30 ◦C. The adsorption kinetics gravitated towards the pseudo-second-order kinetic model. Tan et. al. (2007) studied activated carbons from coconut husk using response surface methodology. Coconut husk was used to prepare activated carbon using physiochemical activation method, consisting of potassium hydroxide (KOH) treatment and carbon dioxide (CO2) gasification. The impacts were activation temperature, activation time and chemical impregnation (KOH: char) ratio on the adsorption capacity on methylene blue dye and carbon yield were studied. Based on the central composite design (CCD), a two factor interaction (2FI) model and a quadratic model were respectively developed to correlate the preparation variables to the adsorption capacity and yield. The optimum conditions for preparing activated carbon from coconut husk were found as follows: activation temperature of 816 ◦C, activation time of 1 h and KOH: char ratio of 3.9.

Emmanuel et. al. (2009) studied multistage optimization of the adsorption of methylene blue dye onto defatted Carica papaya seeds. The adsorption capacities of the defatted Carica papaya seeds were 1250 and 769.23mgg−1. The surface chemistry studies showed the presence of carboxylic acid, phenolic and lactone functional groups and the adsorption of MB dye onto DPS adsorbent was exothermic and spontaneous.

Yang and Qiu (2010) studied vacuum chemical activation and their application for methylene blue removal by the Preparation of activated carbons from walnut shells using. The main process parameters (such as activation temperature, impregnation ratio and system pressure,) on the properties (expressed in terms of specific surface area and pore volume) of the obtained activated carbons were studied. activated carbon pressure of 30 kPa, activation temperature of 450 ◦C, and impregnation ratio of 2.0, BET surface area of 1800m2/g and total pore volume of 1.176cm3/g. The results showed that the methylene blue adsorption capacity was positively correlated to the BET surface area with highest methylene blue adsorption capacity was 315 mg/gfor activated carbon.

Foo and Hameed (2012e) studied coconut husk derived activated carbon via microwave. The chemical impregnation ratio (0.25–2.00), operational parameters of activation agents, microwave power (90– 800 W) and irradiation time (4–8 min) of carbon yield and adsorption capability were studied. CHAC examined pore structural analysis, at best conditions (KOH as activating agent, IR of 1.25, microwave power of 600 W and radiation time of 6 min). CHAC showed monolayer adsorption capacity of 418.15 mg/g for MB and carbon yield of 80.75%, Langmuir isotherm favoured equilibrium data, while the adsorption kinetic fitted to the pseudo-second-order model.

Foo and Hameed (2012b) studied durian shell derived activated carbon through Textural porosity, surface chemistry and adsorptive properties. Activated carbon was derived from durian shell (DSAC) by microwave a NaOH activation. The result shows DSAC with a monolayer adsorption capacity for MB of 410.85 mg/g, while the BET surface area and total pore volume were identified to be 1475.48 m2/g and 0.841 m3/g, respectively.

Foo and Hameed (2012f) studied methylene blue adsorption oil palm fiber activated carbon. The BET surface area, pore volume and average pore size of OPAC were 707.79m2/g, 0.3805m3/g and 22.11A˚, respectively; with microwave power of 360W and irradiation time of 5 min. thus showing microwave heating as an alternative activation technique.

Sener (2008) studied the use of solid wastes of the soda ash plant as an adsorbent for the removal of anionic dyes: the adsorption was strongly pH dependent. As pH increased, extent of dye uptake increased and it matches pseudosecond-order rate expression. The Freundlich isotherm adsorption of the dye on SW while the thermodynamics of PC/SW system indicated spontaneous and exothermic natureof the process.

III. MATERIALS AND METHODOLOGY

A large number of hamburger seed shell were obtained from waste basket sites within Afia nine market, Enugu. The collected samples were deseeded to remove some particles of hamburger seed. The shell was first washed thoroughly with potable water to remove dust, color, and impurities then rinsed with distilled water and oven dried at 110 ºC for 3 hours. After which, the samples were grounded and screened using a mesh size of 3.5mm. The obtained samples were stored for carbonization process.

➢ *Materials*

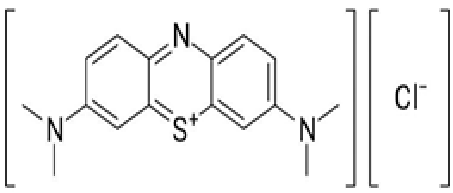
- *Hamburger seed shell*
- *Furnace*
- *Distilled water*
- *Potassium hydroxide (KOH)*
- *Crusher*
- *Dryer*
- *Sieve.*

➢ *Sample Collection and Preparation*

A large number of hamburger seed shell were obtained from waste basket sites within Afia nine market, Enugu. The collected samples were deseeded to remove some particles of hamburger seed. The shell was first washed thoroughly with potable water to remove dust, color, and impurities then rinsed with distilled water and oven dried at 110 º C for 3 h. After which, the samples were grounded and screened using a mesh size of 3.5mm. The obtained samples were stored for carbonization process.

- *Adsorbate*

Methylene blue dye commonly known as methylene blue dye with molecular weight of 319.9 and empirical formula of C16H18N3SCl is used for dying cotton, wood, leather and silk (Tan, et. al., 2007). It is cationic or positively charged and it is absorbed by materials anionic or negatively charged. Methylene blue dye was selected for study because of its known strong adsorption onto solids. The chemical structure of methylene blue dye is shows as follows:



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➢ *Carbonization Process*

This was done using the screened hamburger seed shell. The sample was poured into platinum crucible and then placed into a muffle furnace (carbolite Sheffield England LMF4) which allows limited supply of air. Carbonization was carried at a temperature of 800^0C for 2 hours and allowed to cool at room temperature. The carbonized sample was weighed and stored for activation process.

➢ *Activation Process (Using Potassium Hydroxide)*

In other to study the adsorption strength of the carbonized sample, it was subjected to an alkaline activation using concentrated potassium hydroxide (KoH). The carbonized sample to KoH ratio was 1:1.5 by weight. The mixture was stirred vigorously into thick slurry and maintained agitation for some minutes. The reactor was placed into the muffle furnace at the temperature of 850^0C and allowed for 1hours. After 1 hour, it was brought out from the furnace and allowed to cool at roomtemperature.

The yield of activated carbon was defined as the ratio of weight of final activated products final to the weight of dried precursors. The yield of activated carbon was calculated based on the following equation:

$$\text{Yield}(\%) = \frac{(Wf)}{W0} * 100 \qquad (3.1)$$

Where Wf and W0 were the weight of final activated products (g) and the weight of driedprecursors (g), respectively.

➢ *Preparation of Methylene Blue Dye Stock Solution*

Dissolve l g of Methylene blue in distilled water to obtain 1000 mgL-1 stocksolution of Methylene blue, volume of 1000 mL volumetric flask that was shaken to obtain homogeneity and kept for serial dilution. The final methylene blue concentration was obtained by treating with visible spectrometer, the absorbance values measured at 668 nm (Nwabanne and mordi, 2009).

Fig 1Methylene Blue dye

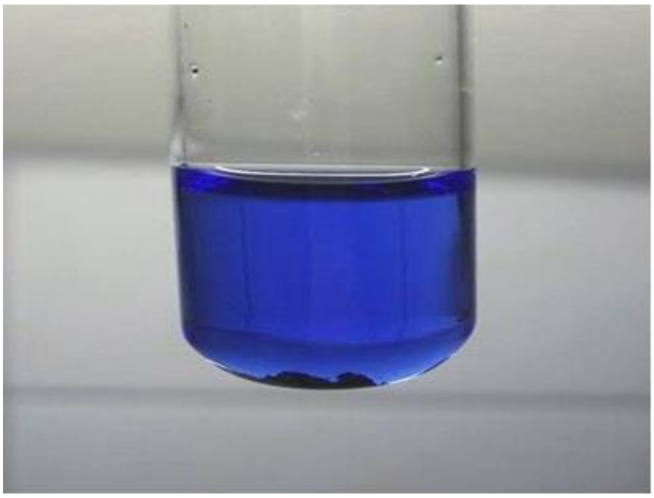

Fig 2 Methylene Blue Solution

➢ *Characterization of Activated Carbon*

The characteristics of the precusor (hamburger seed shell) were examined and its physiochemical properties studied using fourier transformed infrared spectroscopy (FTIR) AND scanning electronmicroscopy (SEM).

➢ *Determination of Surface acidity*

The acidity was obtained by comparing the normal volume used and initial volume used to the ratio of the molecular weight calculated (Nora et.al., 2013).

$$\text{Surfce acidity} = \frac{\text{Normality} \times \text{vol used}}{\text{mol wght}} \times \text{int vol selctd for titration}$$

➢ *Batch Adsorption Studies*

The batch adsorption studies, 200mg of adsorbent (conventionally activated carbon). The prepared initial methylene blue dye concentrations (100-400mg/l) was used to saturate the activated carbon.The activated carbon loaded with dye was immersed in the initial solution of the dye for 24hours, to enable active sites full saturation. After equilibrium, the saturated adsorbents were washed with distilled water in order to remove un-adsorbed traces of the dye adhering on the surface and dried overnight.

IV. RESULTS AND DISCUSSION

Sample Description: Adsorption (Conventionally activated hamburger seed shell)

Analysis Required: Efficiency in Adsorption Conditions for the Treatment of Methylene Blue Dye

➢ *Characteristic Properties of the Conventional Prepared Activated Carbon from Hamburgar Seed Shell (CPAHS)*

Table 1 Characteristic Properties of the Conventional Prepared Activated Carbon

1 Surface Area m2/g 548.6 528.7	430.6	400.9	
2 Iodine Number mgI2/g 1009.3 1001.9	700.3		660.8
3 Moisture Content% 3.6 3.7	3.2		4.0
4 Ash % 3.2	3.8	6.0	3.9
5 Volatile Matter % 3.5 2.8	2.2		3.6
6 Fixed carbon % 89.7	89.7	88.6	88.5
7 pH - - 6.8 6.8	6.9		7.1
8 Bulk Density g/ml 0.50 0.5	0.48		0.51

➢ *FTIR Analysis of Raw Hamburger Seed Shell*

Absorption cm-1	Class of compounds Assignment	Intensity
672.5205	Alkenes =C-H bend	m-s, broad

Table 2 FTIR Analysis of Raw Hamburger Seed Shell

773.2506	Alkyl halides C-CI Stretch	s
1438.687	Methyl group C-H bend	m
1008.632-1140.975	Alkyl halides C-F Stretch	vs
1364.13	Nitro compounds N-O	Symmetric s
1678.557	Ketones C=O Stretch	s
1794.615	Acyl chlorides C=O Stretch	s
2266.137	Alkynes C ≡ C Stretch	vw- w
2531-974-2743.853	Carboxylic acid O-H Stretch	s, broad
2977.829	Alkenes and alkyls C=H stretch	s
3158.33-3385.28	Carboxylic acid O-H Stretch	s, broad
3549.243-3803.987	Water molecules O-H Stretch	s
2266.137	Alkyne C ≡ C Stretch	vw-w

➢ *Summary Results of Calculation of Percentage Removal*

Table 3 Effect of PH

	50mg/L	**80mg/L**
Ph	**% Removal**	**% Removal**
2	84.11	82.23
4	95.00	94.50
6	96.20	95.98
8	97.80	97.40
10	96.75	97.69

Table 4 Effect of Dosage

	50mg/L	**80mg/L**	**110mg/L**
Dosage (g)	**% Removal**	**% Removal**	**% Removal**
0.02	98.75	98.94	96.53
0.05	98.97	99.01	98.09
0.08	99.07	99.14	98.53
0.11	99.36	99.26	98.83
0.14	9.42	99.31	98.73
0.17	99.46	99.36	98.77
0.20	99.50	99.40	98.80

Table 5 Effect of Initial Concentration

INITIAL CONC.	pH4	pH10
(mg/L)	% Removal	% Removal
50	95.00	98.75
80	94.50	97.77
110	92.68	96.53
140	85.15	92.83
180	80.21	82.58

Table 6 Effect of Contact Time

Time	pH2	pH4	pH6	pH8	pH10
(mins)	% Removal	% Removal	% Removal	% Removal	% Removal
20	43.54	84.91	87.80	87.80	94.58
40	64.34	92.49	90.19	93.52	97.06
60	70.85	95.49	94.10	96.89	97.70
80	77.50	97.28	96.93	97.73	98.37
100	81.63	97.92	98.13	98.63	98.89
120	83.57	98.13	98.39	99.00	99.30
160	83.96	98.16	98.56	99.10	99.35
180	84.39	98.16	98.59	99.16	99.40
240	84.39	98.16	98.59	99.16	99.40

- *Summary of Effects of PH, Time and Adsorbate Dosage on Adsorptive Capacity Effect ofPH*

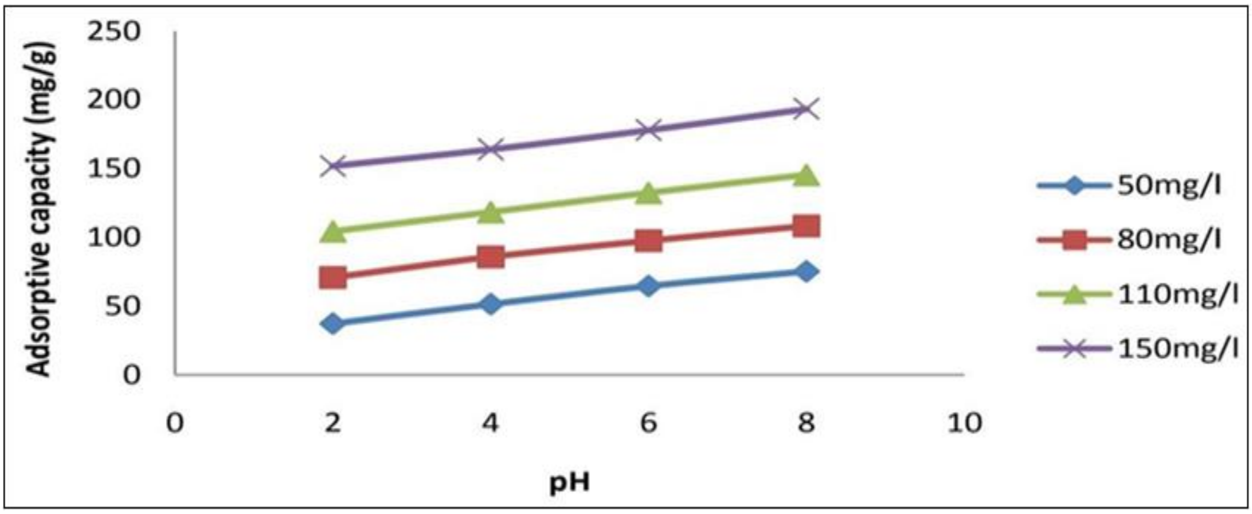

Fig 3 Effect of PH on Adsorptive Capacity at Varying Initial ConcentrationsEffect of Time

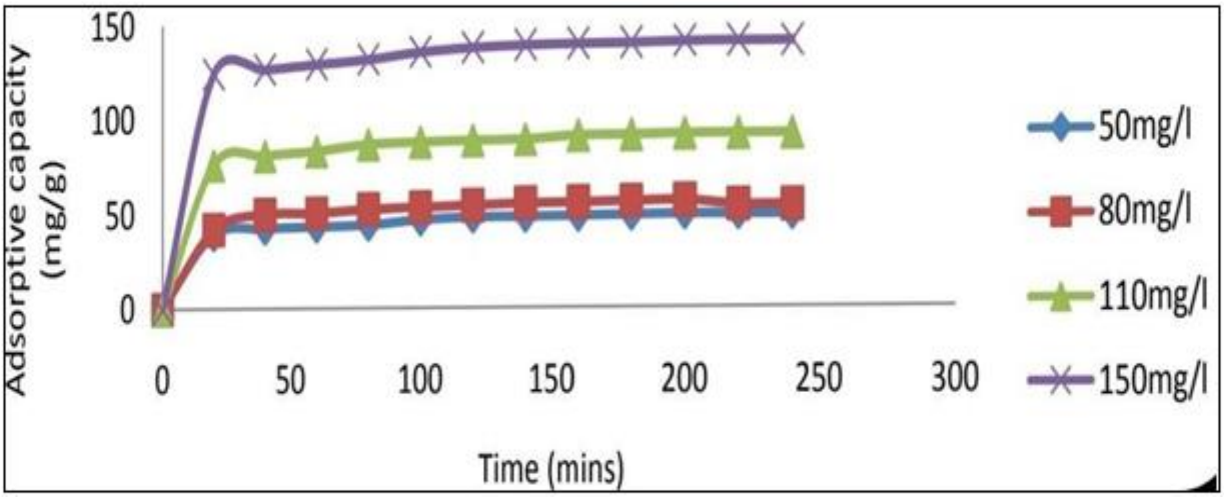

Fig 4 Effect of Time on Adsorptive Capacity at Varying Initial ConcentrationsEffect of Adsorbate Dosage

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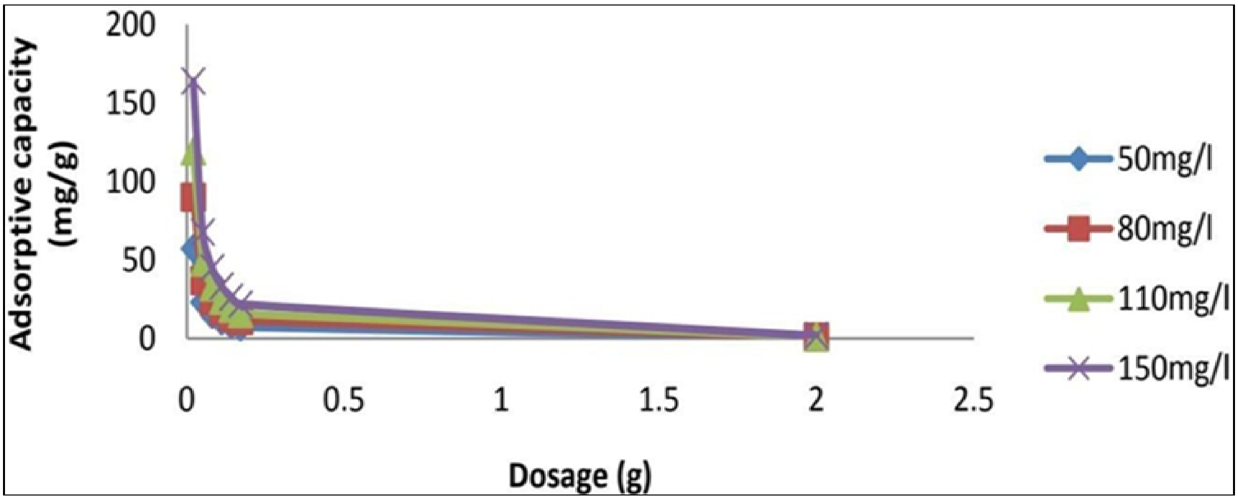

Fig 5 Effect of adsorbate dosage on adsorptive capacity

- *Isotherm Data for Methylene Blue Dye Adsorption on Conventional Prepared ActivatedCarbon from Hamburger Seed Shell (CPAHS) Langmui*

Table 7 Isotherm Data for Methylene Blue Dye Adsorption on Conventional Prepared ActivatedCarbon

b(mg/g)	0.083 0.146	0.0138	0.0098
kL(L/mg)	0.0565 0.1049	0.0673	0.0226
RL	0.37 0.24	0.33	0.596
	Freundlich		
1/n	0.44 0.2501	0.3034	0.5736
KF (1017)(L/mg)	16.09 20.95	16.029	5.63
R2		0.963 0.939 0.931 0.991	

- *Analysis*

The purpose of this research work is to study the adsorption of methylene blue dye using conventionally activated hamburgers seed shell. The production of activated carbon from agricultural by-product has potential economic and environmental impact.

In this research two method were used in the production of the activated carbon from hamburger seed shell; they are carbonization and activation processes.

V. RECOMMENDATION

The experiment is on the Treatment of methylene blue dye using activated hamburger seed shell. The removal of methylene blue dye from aqueous solution is primary controlled by dye concentration, the adsorbent dosage and the pH of dye solution. The percentage of dye removal was found to increase with increase in contact time, pH and adsorbent dosage and found to decrease with an increase in dye initial concentration. As a result of this study, activated carbon prepared from hamburger seed shells can be used as an effective adsorbent for the removal of methylene blue dye from waste water and other industrial effluent.

From the experiment it was noted that the best pH is pH10. The best initial concentration was also found to be 50mg/L while the best time is 3 hours.

Also it is found that, agricultural by-product such as hamburger seed shell has potential economic and environmental benefits. The conversion of unwanted low value agricultural waste to useful high value adsorptions for the removal of odour and other organic chemicals and metals of environmental concern can be of great important to chemical engineers researches especially in the area of pollution control and water treatment.

Finally, the use of local agricultural raw material for the production of adsorbent such as activated carbon made from hamburger seed shell for removal of methylene blue dye solution from industrialeffluent is recommended.

VI. CONCLUSION

The use of activated carbon produced conventionally using hamburger seed shell is highlyrecommended because not only that the material is easily available at cheaper rate but also becauseit is very safe. It has no effect on the living things, hence its wider application in other areas of treatment.

In the bleaching process using activated carbon, the corrosive nature of activating agent contradictsthe safe nature of the original carbon. Therefore, it is recommended that the activated carbon be desulphurized after activation before bleaching, to curtail the obnoxious effects of the base (KoH) to the finished product. (Activated carbon).

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After washing, it is recommended that the sample should be allowed to dry properly so as to get the accurate weight of activated carbon used during adsorption process.

In the study of adsorption using activated carbon as the adsorbent, it is recommended that adequateequipment should be provided to give an approximate and accurate result.

During carbonization process, it is recommended that the crucible should be properly covered and its temperature during carbonization should be well monitored to prevent ashes.

Further study is recommended to improve or optimize the preparation of the activated hamburgerseed shell and the adsorption of methylene blue dye on it.

REFERENCES

[1]. Ahmad, A; Mohd-Setapar, SH; Chuong, CS; Khatoon, A; Wani, WA; Kumar, R; Rafatullah, M. (2015). Recent advances in new generation dye removal technologies: novel search for approaches to reprocess wastewater. RSC Advances, 5(39), 30801-30818.

[2]. Ahmad, M. A. & Alrozi, R. (2010). Optimization of preparation conditions for mangosteen peel-based activated carbons for the removal of Remazol Brilliant Blue R using response surface methodology.

[3]. Chemical Engineering Journal,165: 883-890.

[4]. Ahmadpour, A. & Do, D.D. (1996). The preparation of active carbon from coal by chemical and physical activation. Carbon, 34: 471-479.

[5]. Aksu Z. (2005). “Application of biosorption for the removel of organic pollutants: A review.Proc.Biochem. 40: 997-1026.

[6]. Aljeboree, AM; Alshirifi, AN; Alkaim, AF. (2017). Kinetics and equilibrium study for the adsorption of textile dyes on coconut shell activated carbon. Arabian journal of chemistry, 10, S3381-S3393.

[7]. Alshabanat M ,.Alsenani G. and Almufarij R (.2013 .)Research Article Removal of Crystal Violet Dye from Aqueous Solutions onto Date Palm Fiber .Chemistry ,.9:1-6.

[8]. Auta, M. & Hameed, B. H. (2011). Optimization of waste tea activated carbon for adsorption of MB and Acid Blue 29 dyes using Response surface methodology . Chemical Engineering journal 175: 233-243.

[9]. Bansal, R.C. Donnet, J.B. & Stoeckli, H.F. (1988). Active carbon. Marcel Dekker, New York.

[10]. Bharathi K. S. and Ramesh S. T.(2013). Removal of dyes using agricultural waste as low-costadsorbents:a review. J.Appl. Water Sci ., 3:773–790.

[11]. Bouasla, F. Ismail, and M. E. H. Samar, “Effects of operator parameters, anions and cations on the degradation of AY99 in an aqueous solution using Fenton’s reagent. Optimization and kinetics study,” Int. J. Ind. Chem., vol. 3, pp. 1-11, 2012.

[12]. Brillas, E; Martínez-Huitle, CA. (2015). Decontamination of wastewaters containing synthetic organic dyes by electrochemical methods. An updated review. Applied Catalysis B: Environmental, 166, 603-643.

[13]. Davoud B., Edris B. and Ferdos K. M.(2016). Equilibrium, Kinetic Studies on the Adsorption of Acid Green 3 (Ag3) Dye Onto Azolla filiculoides as Adosorbent. J. Am. Chem. Sci., 11(1): 1-10.

[14]. Emmanuel, U. I. Gilbert, U. A. Lora, O. O. & Olalere, G. A. (2009). Multistage optimization of the adsorption of methylene blue dye onto defatted Carica papaya seeds. Chemical Engineering Journal, 155: 567–579.

[15]. Ertugay, N; Acar, FN. (2017). Removal of COD and color from Direct Blue 71 azo dye wastewater by Fenton’s oxidation: Kinetic study. Arabian Journal of Chemistry, 10, S1158-S1163.

[16]. Foo, K.Y. & Hameed, B.H. (2009). Recent developments in the preparation and regeneration of activated carbons by microwaves. Advance Colloid Interface Science 149: 19–27.

[17]. Foo, K.Y. & Hameed, B.H. (2010). Recent developments in the preparation and regeneration of activated carbons by microwaves, Advances of Colloid interface Science 149: 19-27.

[18]. Foo K.Y. and Hameed B.H. (2012a). Microwave-assisted regeneration of activated carbon. Bioresource Technology 119: 234-240.

[19]. Foo K.Y. & Hameed B.H. (2012b). Textural porosity, surface chemistry and adsorptive properties ofdurain shell derived activated carbon prepared by microwave assisted NAOH activation Chemical Engineering Journal 189: 53-62.

[20]. Foo, K.Y. & Hameed, B.H., (2012f). Microwave-assisted preparation of oil palm fiber activated carbon for methylene blue adsorption. Chemical Engineering Journal 166: 792–795.

[21]. Gbekeloluwa O., JamesH. and Dong H.(2014). Biosorption of Azure Dye with Sunflower Seed Hull: Estimation of Equilibriu, Thermodynamic and Kinetic Parameters. Int. Eng. Res.Develop.,10(6): 26-41.

[22]. Gottipati, R. (2012). Preparation and Characterisation of microporus activated carbon from biomass and its application on the removal of chromium (VI) from aqueous phase. Unpublished PhD thesis, Department of Chemical Engineering Natural Institute of Technology Rourkela Odisha.

[23]. Kyzas, GZ; Siafaka, PI; Pavlidou, EG; Chrissafis, KJ; Bikiaris, DN. (2015). Synthesis and adsorption application of succinyl-grafted chitosan for the simultaneous removal of zinc and cationic dye from binary hazardous mixtures. Chemical Engineering Journal, 259, 438-448.

[24]. Liu, S.X. Wang, Y. & Zhang, W.C. (2001). Progress in Activated Carbon Regeneration, Carbon Techniques, 29: 61.

[25]. Mohammed B. A.(2014). Removal of Textile Dyes (Maxilon Blue, and Methyl Orange) by Date Stones Activated Carbon. Int. J. Advan. Res. Chem. Sci., 1(1): 48-59.

ISSN No:-2456-2165

[26]. Mullick, A; Moulik, S; Bhattacharjee, S. (2018). Removal of Hexavalent Chromium from Aqueous Solutions by Low-Cost Rice Husk-Based Activated Carbon: Kinetic and Thermodynamic Studies. Indian Chemical Engineer, 60(1), 58-71.

[27]. Nahm, S. W. Wang, G. S. Young – Kwon, P. & Sanng, C. K. (2012). Thermal and Chemical Regeneration of Spent Activate carbon and Its Adsorption Property for toluene. Chemical EngineeringJournal, 210: 500 – 509.

[28]. Nwabanne, J.T. & Igbokwe, P. K. (2012b). Comparative Study of Lead (II) Removal from Aqueous Solution Using Different Adsorbents. International Journal of Engineering Research and Applications(IJERA), 2(4): 1830-1838.

[29]. Oin, Y.C. Wang, H.T. & Zhu, H.Z. (2001). Regeneration Methods of Activated carbon, Carbon Techniques. 117: 29.

[30]. Pagga U, and Brown D. 1986. “The degradation of dyestuffs : part II behaviour of dyestuffs in aerobic biodegradation tests. Chemosphere”. 15: 479-491.

[31]. Pragathiswaran C., Anantha K. N., Mahin A. B., Govindhan P. and Syed A. K.A.(2016). Adsorption of methylene blue dye using activated carbon from the gloriosa superba stem. Int. J. Res. Pharm.Chem., 6(1): 95-103.

[32]. Sara D. and Tushar K. S. (2014). Review on Dye Removal from Its Aqueous Solution into Alternative Cost Effective and Non-Conventional Adsorbents. J. Chem . Proc Eng .,1: 104.

[33]. Sener, S. (2008). Use of Solid Waste of the Soda Ash Plant as an Adsorbent for the removal of AnionicDye: Equilirium and Kinetic Studies. Chemical Engineering Journal 138: 207 – 214.

[34]. Tan, I.A.W. Hameed, B.H. & Ahmad, A.L. (2007). Equilibrium and kinetic studies on basic dye adsorption by oil palm fibre activated carbon. Chemical Engineering Journal 127: 111–119.

[35]. Villet, V. B. M. (1991). The regeneration of activated carbon Journal of the southern African institute of mining and metallurgy. 91(5): 159-167.

[36]. Yang, J. & Qju, K. (2010). Preparation of Activated carbon from Walnut Shell Via Application for Methylene Blue Removal. Chemical Engineering Journal 162:209 – 219.

[37]. Zhang, L. Su, M. & Guo, X. (2008). Studies on the treatment of brilliant green solution by combination microwave induced oxidation with CoFe2O4, Seperation Purification Technology 62: 458–463.