DIJBAR
www.daagu.org
Volume-3 Issue-2

STUDY OF ADSORPTION EFFICACY OF ADANSONIA DIGITATA (BAOBAB) WOOD BLENDED WITH MUSA ACUMINATA STEM POWDER

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ABSTRACT

In continuation of our research work in the area of developing adsorbents from agricultural wastes, a mixture of adsorbents is chosen in the present study. A novel adsorbent obtained by blending adansonia digitata (baobab) wood and musa acuminata stem (1:1 w/w) has been used for the removal of congo red dye using simulated aqueous solutions employing adsorption method. The degree of adsorption was studied by using different parameters such as pH (2-8), contact time (50-150 min), initial dye concentration (50-150 mg/l) and adsorbent dosage (0.5-2 g). The extent of adsorption was determined by employing UV-Vis spectrometer. The experimental data was verified by Freundlich model and found to be in agreement. Under the experimental conditions the parameters at the maximum adsorption ability have been determined for the dye and reported.

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Keywords: biosorption, congo red dye, baobab wood adsorbent and musa acuminata stem adsorbent

Citation: study of adsorption efficacy of adansonia digitata (baobab) wood blended with musa acuminata stem powder , Daagu International Journal of Basic & Applied Research-DIJBAR. Volume3, Issue-2, pp (45-54)

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Received: 14-12-2021

Accepted: 25/12/2021

Published: 30/12/2021

OPEN ACCESS

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1. INTRODUCTION

The removal of color from dye-bearing effluents is posing a threat nowadays due to the limitations of conventional treatment methods. It is evident that low-cost adsorbents have demonstrated considerable removable capabilities for dyes. A review of feasibility of agricultural waste adsorbents for dye removal shows that most of them act as substitutes for expensive activated carbon adsorbents but complete dye removal is not possible (Kayado et al., 2015). Bagasse and corncob wastes have shown that removal of dyes is favorable (R.S.Juang et al., 2002). The presence of tiny amounts of dye in water (less than 1 ppm) is also highly visible and undesirable (L.Lian et al., 2009). Recent advances in remediation of synthetic dyes from waste waters using sustainable and low cost adsorbents show the impact and prospects (Sharf et al., 2019). Dyes are synthetic aromatic compounds that are stable and hardly undergo natural degradation (yenikaya, et al., 2010). Most of the dyes are complex organic molecules. Azo dyes are the mostly used in industrial activities. Dyes are used in production of the essential consumer products of modern life such as textile, leather, cosmetic, foods and beverages, papers and pulp which cause the environmental pollution problems and threat to the ecological balance (Ulas, et al., 2017). Dyes are produced, utilized and partially released into atmosphere after the application is over. Synthetic dyes are extensively used for coloring and printing in variety of industry (mohanraj, 2009). Biosorption of textile effluents was studied extensively and reported (Omprakash et al., 2018). Many researchers found that colorant may cause problems in aquatic ecosystem in several ways (yenikaya, et al., 2010). Worldwide, infectious diseases such as water-borne diseases are a serious threat to children under five years old and more people die from unsafe water (Edogbanya, et al., 2013a). Every day, more than two million tons of sewage, industrial and agricultural waste is discharged into the world's waste water bodies (WWAD, 2006). There are several ways for removal of dyes; adsorption has been considered as one of the safest and simple methods for the removal of textile dye effluents due to its low cost, easy availability, simplicity of design, high efficiency, ease of operations and ability to treat wide variety of dyes (Ramalakshmi et al., 2012). Activated carbon is a carbonaceous adsorbent with a highly crystalline form and internal pore structure (Kavitha 2019). A wide variety of activated carbon products are available depending upon a starting raw material and activation techniques (Gupta, 2003).

In continuation of our investigation using adansonia digitata stem adsorbent for the removal of methylene blue (Mihayo et al., 2020), favorable adsorption was observed for congo red dye also (Mastan Rao K et al., 2021). The present study attempts to make a blended adsorbent obtained from adansonia digitata (baobab)

wood powder and musa acuminata stem powder for the adsorption of simulated congo red dye solutions. The Baobab tree mostly found in the equatorial area such as Gabon, Democratic Congo, Zaire and the area with marked dry season (Gebauer, et al., 2002) such as Dodoma region in Tanzania. Generally baobab fruits and seed oil are used for human consumption and the rest of the tree parts are used as traditional medicine (simon, 2015). Baobab belongs to genus: adansonia and species-adansonia digitata. Several varieties of musa acuminata are grown in Tanzania. An attempt is made to study the adsorption of this biosorbent towards removal of organic dye.

2. MATERIALS AND METHODS

2.1 Preparation of dye solution

Stock solution of dye concentration 1000 mg/l was prepared by dissolving 1g of 100% pure congo red dye in 1000ml of distilled water by using standard flasks. Solutions of different concentrations were prepared by dilution method between 20 and 200 mg/l using the above stock solution of the dye. All chemicals of 99.9% purity have been used in the present study.

2.2 Preparation of adsorbent from adansonia digitata wood and musa acuminata stem powder

Hard wood of adansonia digitata has been collected from a single tree in Dodoma region at Kongwa district. After removing the bark, small chips of the baobab wood are pulverized into powder using grinding machine and then sieved through a pore size of about less than one millimeter. Musa acuminata stem was collected from Msalato (Tanzania) area and washed with distilled water to remove dirt and was cut into small particles size in the range of 5 to 7 cm. The sample was dried in an oven until constant weight and it was cooled for one and half hour and crushed into fine powder. Both the samples obtained from baobab and musa acuminata are mixed in 1:1 weight ratio, dried and ground to get a powder of particle size about 125-250 µm range and stored in an airtight container for further experiments.

2.3 Batch mode biosorption studies

A standard calibration plot between the adsorbate concentration and absorbance was drawn. Batch biosorption equilibrium experiments were conducted in 250 ml conical flasks at a constant agitation speed (180 rpm). All the experiments were carried out at room temperature (30^0C). The concentrations of the dye both before and after adsorption were determined using Agilent 60 Cary UV- Vis spectrophotometer, USA through monitoring the absorbance for the dye used. In the present study, the effect of initial concentration of the dye, adsorbent dosage, pH of solution and contact time on adsorption have been studied. The effect of initial dye concentration was studied in the concentration range 50-150 mg/l. The effect of pH on adsorption process was studied in the pH intervals of 2, 4, 6 and 8. The effect of mass of adsorbent was studied

in the range of 0.5gram to 2gram at constant dye concentration 100 mg/l and optimized conditions. The effect of contact time was studied in the constant dye concentration of 100 mg/l and time range from 50 minutes to 200 minutes.

3. RESULTS AND DISCUSSION

3.1 Effect of initial concentration of dye

The effect of initial dye concentration was studied in the concentration range 50-150 mg/l. The extent of adsorption of dye per gram of adsorbent was calculated and reported in Table 1. A plot is drawn between adsorbate concentration and adsorption ability and shown in figure.1.

Table 1. Initial dye concentration versus. absorbance data

S. No.	C_i (ppm)	m (g)	absorption	C_f (ppm)	C_i-C_f = x	x/m	log C_i	log x/m
1	50	1	0.6212	44.3	5.70	5.70	1.699	0.756
2	100	1	1.9877	77.5	22.55	22.55	2.000	1.353
3	120	1	3.2156	90.5	29.55	29.55	2.079	1.470
4	150	1	3.8836	117.3	32.67	32.67	2.176	1.514

x/m=extent of adsorption (mg/g), C_i=initial concentration of dye (mg/l), C_f = final concentrations of dye (mg/l) , w = dry weight of the adsorbent (g)

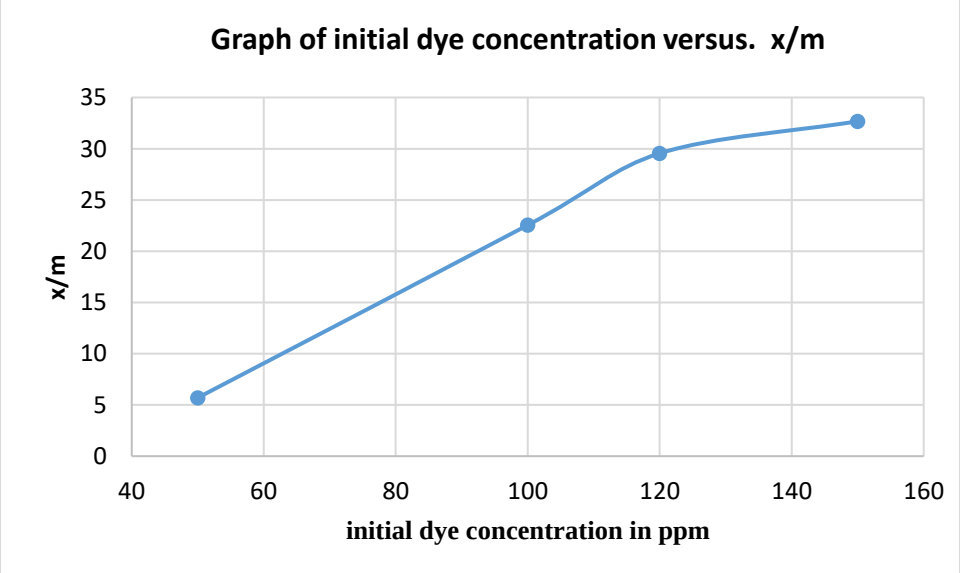


Figure 1. Graph of initial dye concentration versus. adsorption ability

3.2 Adsorption isotherm

Adsorption isotherm has been studied on the extent of adsorption of CR dye on the adsorbent by using Freundlich adsorption model. According to the Freundlich isotherm model, the amount of adsorption at low concentration varies linearly, at moderate concentration becomes dependent on the Freundlich constant and at higher concentration becomes independent of the adsorbate concentration. From the figure 1 above, it is observed that the experimental results obey the Freundlich model satisfactorily. Further it is verified by plotting a logarithmic graph (figure 2) and found to be a straight line which is expected of the above results.

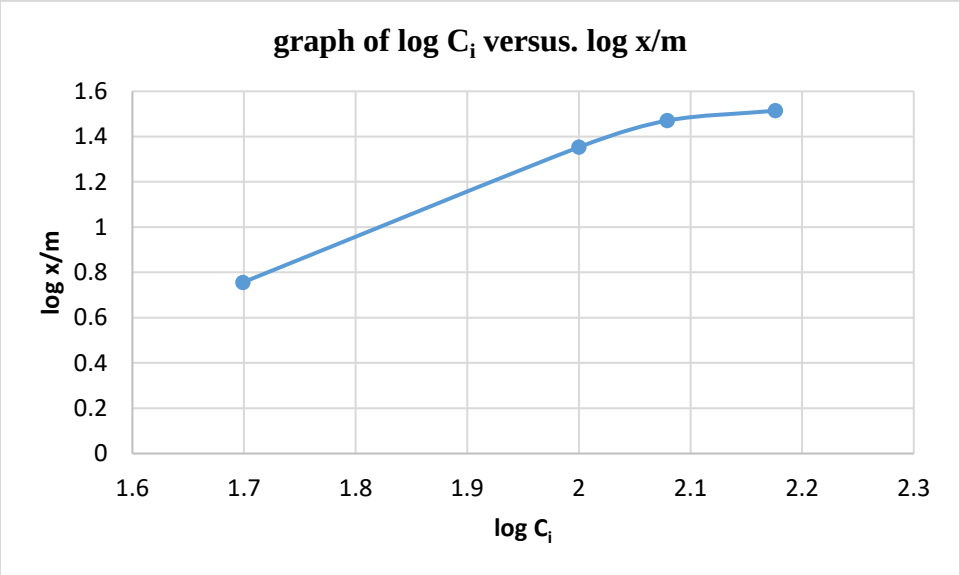


Figure 2. Freundlich adsorption isotherm for the adsorption of congo red dye on adsorbent.

It is observed from the graph that as the initial concentration of adsorbate increases, adsorption ability increases to a certain extent and thereby remains constant. This may be due to the saturation of the active sites of the adsorbent upon adsorption of the dye molecules.

3.3 Effect of adsorbent dosage

The effect of mass of absorbent was studied in the range of 0.5 g to 1.5 g at constant adsorbate concentration of 100 mg/l. The extent of adsorption of dye per gram of adsorbent was calculated and reported in Table 2. A plot drawn between adsorbent dosage and adsorption percentage is shown in the figure 3.

Table 2. Data showing adsorbent dosage % removal of adsorbate

S. No.	C_i (ppm)	m (g)	absorbance	C_f	C_i-C_f = x	x/m	% removal
1	100	0.5	2.193	80.81	19.19	38.39	19.19
2	100	1.0	1.867	69.23	30.77	30.74	30.74
3	100	1.2	1.733	64.52	35.48	29.56	35.47
4	100	1.5	1.527	57.20	42.80	28.54	42.80

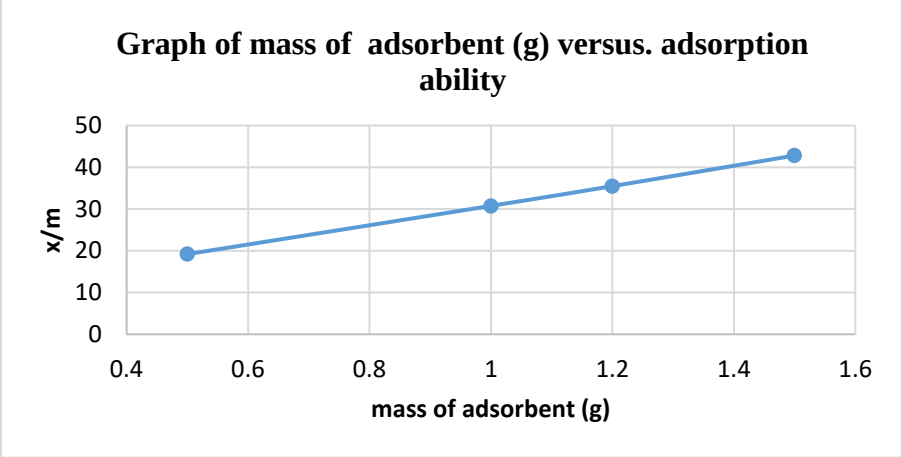


Figure 3. Graph of mass of adsorbent versus adsorption ability

It was observed that the extent of adsorption increases with an increase in the mass of adsorbent from 0.5 -2.0 gram which may be due to the availability of unsaturated surface area (active sites). Further the values of (C_i-C_f)/m are decreasing which can be attributed to the less concentration of dye molecules available per gram of adsorbent.

3.4 Effect of pH

The effect of pH was studied at a constant concentration of 100 mg/l of adsorbent and pH range 2-8. The extent of adsorption of dye per gram of activated carbon was calculated and reported in Table 3.

Table 3. Effect of pH on the adsorption ability of the adsorbent

S. No.	C_i (ppm)	m (g)	pH	absorbance	C_f (ppm)	C_i-C_f = x	x/m	% removal
1	100	1.51	2.38	0.8998	34.9539	65.0461	43.3641	65.04
2	100	1.50	4.45	1.5847	59.2411	40.7589	27.1726	40.75
3	100	1.50	6.24	2.1563	79.5106	20.4894	13.6596	20.48
4	100	1.50	8.14	2.4313	89.2624	10.7376	7.1584	10.73

x/w = extent of adsorption (mg/g), C_i = initial concentrations (mg/l), C_f = final concentrations of dye (mg/l) , m = dry weight of the activated carbon (g), the percentage of adsorption of the dye $q\% = \frac{(Ci-Cf)}{Ci}$.

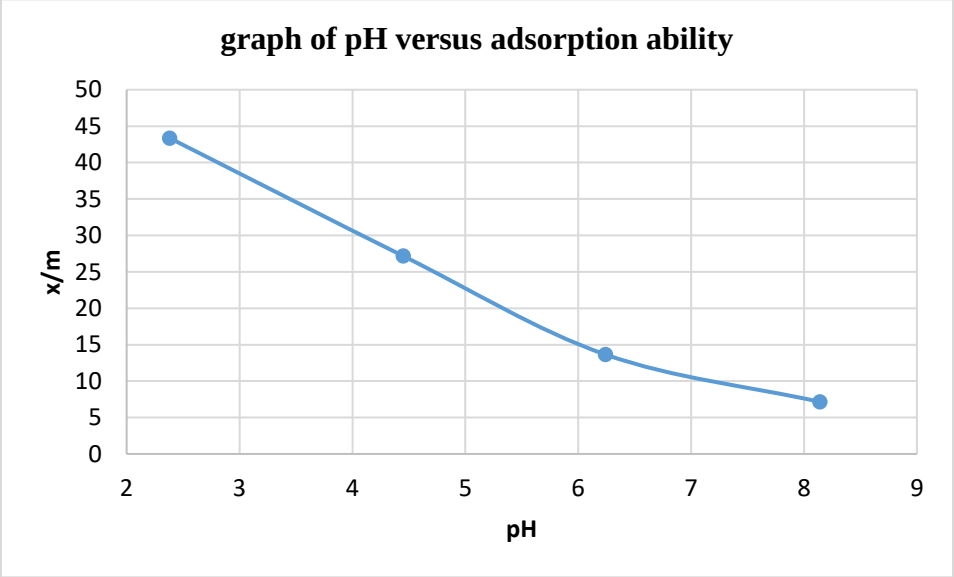


Figure 4. The Graph of pH versus adsorption ability.

The adsorbate shows a maximum adsorption at pH 2.46 with maximum percentage of adsorption of 98.9%, because it works efficiently on the acidic medium than in a basic medium. Congo red is an anionic azo dye; hence at lower pH it shows higher adsorption due to the positively charged surface of the adsorbent.

3.5 Effect of contact time

The effect of contact time was studied at a constant concentration of 100 mg/l and time range from 50 minutes to 120 minutes. The extent of adsorption of dye per gram of activated carbon was calculated and reported in Table 4 below.

Table 4. Effect of contact time on adsorption

S. No.	C_i (ppm)	m (g)	time (min)	absorbance	C_f (ppm)	$C_i - C_f = x$	x/m	% removal
1	100	1.0	30	1.328	50.13	39.31	39.31	39.30
2	100	1.1	60	1.023	39.31	60.69	55.18	60.69
3	100	1.1	90	0.664	26.60	73.40	66.72	73.39
4	100	1.1	120	0.302	13.78	86.22	78.40	86.22

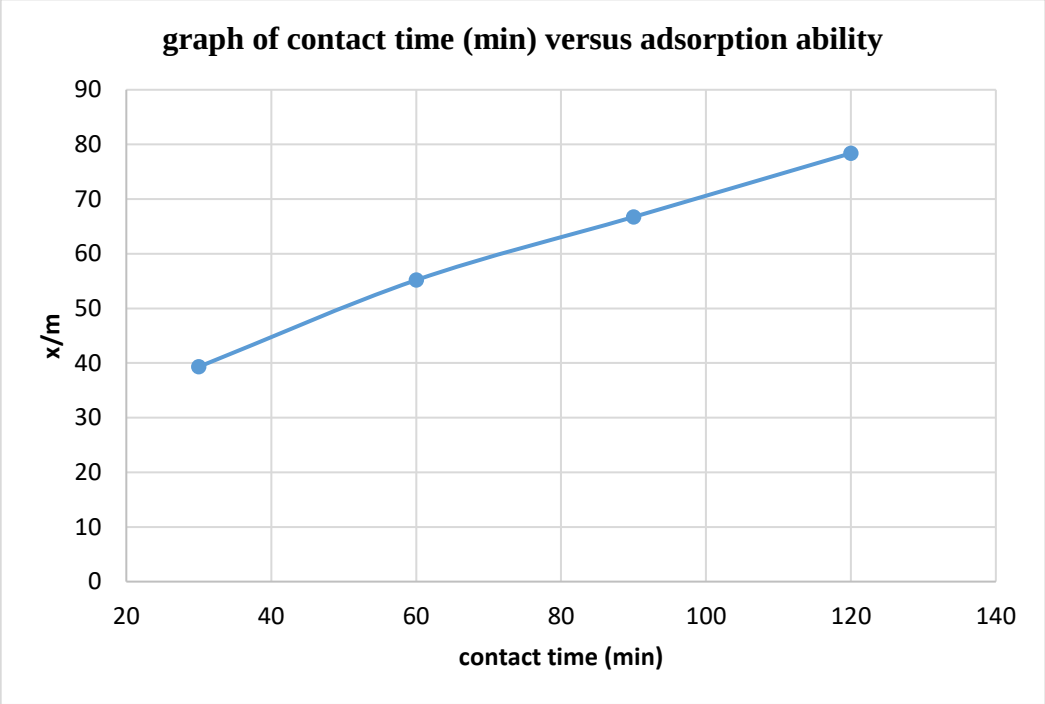


Figure 5. Graph of contact time (min) versus adsorption ability.

As seen in figure 5, it is evident that time has significant influence on the adsorption of dye at the initial concentration of 100 mg/l. The removal of congo red dye by the adsorbent blend as a function of time was observed. Initially, the adsorption of dye is considerable during the time interval of 50 to 150 min and later, the adsorption process becomes less significant and remains nearly constant. The adsorption efficiency was

found to be 98.25%. Based on these results 120 minutes was taken as the maximum time required to reach equilibrium state in batch adsorption experiment.

4. CONCLUSIONS

The data obtained from the above studies showed that a contact time of 150 min was sufficient for the maximum removal of congo red dye from aqueous solutions using baobab wood charcoal mixed with musa acuminata stem powder. The experimental data of biosorption of the dye on the biosorbent fits well with the Freundlich adsorption model. This indicates that the biosorption of the dye on the biosorbent is favorable. The maximum removal efficiency was found at a temperature of 303K, at solution pH of 2.38, initial dye concentration of 150 mg/l and biosorbent dosage of 4.0g under the experimental conditions. Further investigation of the adsorption characteristics like surface area of the adsorbent and adsorption thickness is suggested to understand the adsorption mechanism.

ACKNOWLEDGEMENTS: The authors sincerely express their gratefulness to the authorities of The University of Dodoma, Dodoma, Tanzania for providing financial support and laboratory facilities.

REFERENCES

1. **Anna Chladova and Kathleen Prinz (2019),** Genetic diversity and structure of baobab (adansonia digitata L.) in southeastern kenya, Royal Society Open Science, 6 (9) 190854.
2. **David Mihayo et al., (2020),** Kinetic study of adsorption of methyl red dye on pericarp charcoal of adansonia digitata(Baobab), International Journal of Basic and Applied Research, DIJBAR, vol.2, issue 2**,** pp42-50
3. **Edogbanya P.R.O, Ocholi O.J and Y Apeji (2013a),** A review on the use of plant seed as biocoagulants in purification of water, Continental J.of Biological Sciences 6(2) pp26-32.
4. **Gebauer J, El-sidding K and Elbert (2002),** G Baobab (adansonia digitata): A review on multipurpose tree, Gartenbauwissenschaft, 7(4) 155-160.
5. **Gupta, V. K., I. Ali, and Dinesh Mohan (2003)**, Equilibrium uptake and sorption dynamics for the removal of a basic dye (basic red) using low-cost adsorbents, Journal of colloid and interface science, 265 (2) 257-264.
6. **Kavitha, D and C. Namasivayam (2007), ,** Experimental and kinetic studies on methylene blue adsorption by coir pith carbon. Bio-resource Technology, 98 (1) (2007) 14-21.
7. **Kayado Adesina Adegoke et al., (2015),** Dye sequestration using agricultural wastes as adsorbents, Water Resources Industry, Vol. 12, pp8-24
8. **L.Lian et al., (2009),** Adsorption of congo red from aqueous solution onto Ca-bentonite, J.Hazard. Mater.161, pp 126-131.

9. **David Mihayo et al., (2020),** Kinetic study of adsorption of methyl red dye on pericarp charcoal of adansonia digitata(Baobab), International Journal of Basic and Applied Research, DIJBAR, vol.2, issue 2**,** pp42-50
10. **Mastan Rao K et al., (2021),** Kinetic study of adsorption of congo red dye on wood charcoal of adansonia digitata(Baobab), International Journal of Basic and Applied Research, DIJBAR, vol.2, issue 1**,** pp82-91
11. **Mohanraj Rangaswamy (2009)**, Adsorption of crystal violet dye from aqueous solution using Eicinus Communis pericarp carbon as an adsorbent, E-Journal of Chemistry, 6(4) pp1109-1116.
12. **Omprakash Sahu and Nagender Singh (2018),** Significance of biosorption process on textile industry waste water, Impact and Prospects of Green Chemistry for Textile technology(pp 367-416).
13. **Ramalakshmi S and Muthucheliam K (2012),** Comparatives studies on removal of fast green dyes from aqeous solution by activated carbon prepared from Gloriosa superba waste and alternaria raphani fungal biomass, Journal of Environmental Science and Technology (5) 222-231.
14. **R.S.Juang et al., (2002),** Adsorption of dyes and phenols from water on the activated carbons from corncob wastes, Environ. Technol., 22, pp 205-213.
15**. Sharf Ilahi et al., (2019),** Impact and Prospects of Green Chemistry for textile Technology,
pp 471-507.
16. **Singh Nagender (2019),** Impact and prospect of green chemistry for textile technology Book Review.
17. **Sircar S and Rao B.M (1996),** Activated carbon for gas separation and storage, Carbon, 34(1) pp1-12.
18. **Simon J (2015),** Baobab: the tree of life- An Ethnopharmacological review, The Journal of the American Botanical Council, (108) pp42-53.
19. **Ulas Calisir and kiline Namlik (2017),** Biosorption for dyes removal from industrial waste water Int.J.Adv.Res.5(8),707-714.
20. **Yenikaya Cengiz. and Atar Emrah(** 2010), Biosorption study of anionic dye from aqoues solution using bacillus amyloliquefaciens, Wiley online library, (10) pp233-241 https://doi.org/10.1002/elsc.200900108.