

Removal of Colour from textile effluent by adsorption using low cost adsorbents

ABSTRACT

Aims: A study was undertaken to investigate the removal of dye from synthetic and industrial effluents by adsorption process in order to achieve better removal efficiency.

Methodology: Acid orange 7, an anionic dye is used as an adsorbate for the present study. The study was conducted by using two different adsorbents such as Granular activated carbon of coconut shell (GAC) and coal ash. The study was carried out by conducting both batch mode and column mode experiments. Operating parameters such as pH, effective dosage, and contact time were optimized by conducting batch experiment. Column studies were conducted in order to determine the saturation time by using column Break-through curve. Both freundlich and Langmuir isotherm were plotted.

Results: As a result, pH of 6, dosage of 1.5gm/100ml and contact time of 15 minutes were found to be optimized condition for the colour removal by GAC and coal ash. Colour removal of about 94% and 85% were obtained at pH 6 for an adsorbent dosage of 1.5g/100ml of 50 mg/l and 100 mg/l dye concentration respectively for GAC and Colour removal of about 80% and 75% were obtained at pH 6 for an adsorbent dosage of 1.5g/100ml of 50 mg/l and 100 mg/l dye concentration respectively for Coal ash. GAC took 286 and 218 hours to get saturated for 50mg/l and 100mg/l respectively and coal ash took 145 and 96 hours to get saturated for 50mg/l and 100mg/l respectively. Results obtained on industrial wastewater showed the results were in par with the synthetic sample.

Conclusion: From the batch and column studies it can be concluded that increase in adsorbent dosage increased the percentage removal of dyes and higher initial concentration resulted in shorter column saturation time respectively. Langmuir isotherm was found to be best fit for both the adsorbents.

Keywords: Adsorption, colour removal, Granular activated carbon, Coal-ash and Isotherms

1. INTRODUCTION

Our earth is the only planet in the whole universe, accredited to have life. One of the prime reasons, which support life in our mother-planet, is water. But, anthropogenic activities have caused a great harm to the quality of our lifeline, i.e. water. Because of fast depletion of the freshwater resources, there seems to be a crisis of the same [1]. Presently, it was estimated about 10,000 of different commercial dyes and pigments exist and over 7 x 10⁵ tones are produced annually worldwide [2]. Dyes are widely used in industries such as textile, rubber, paper, plastic, cosmetic etc. Among these various industries, textile ranks first in usage of dyes for coloration of fibre [3]. The colour in the effluent is mainly due to unfixed dye. The concentration of unused dyes in the effluent depends upon the nature of dyes and dyeing process [4]. One of the major problems concerning textile effluent is coloured effluent. The release of the colored dyes into the ecosystem is a dramatic source of aesthetic pollution, of eutrophication, and of perturbations in aquatic life [5]. In addition, colour interferes with the transmission of sunlight into the stream and therefore reduces photosynthetic action [6]. Dyes even in low concentrations affect the aquatic life and food web. Since many organic dyes are harmful to human beings, the removal of colour becomes important [7].

Conventional methods for removing dyes include adsorption, electrocoagulation, ozonation, ultrafiltration, reverse osmosis, flocculation, oxidation, ion-exchange, etc. [8]. Adsorption has been found to be highly efficient for the removal of colour in terms of ease of operation, initial cost, simplicity of design [9] and sludge free process [10]. The most commonly used adsorbent for colour

removal is activated carbon, because of its capability for efficiently adsorbing a broad range of different types of adsorbate [11].

In the present study the adsorption of acid orange 7 dye onto GAC of coconut shell and coal ash have been investigated. The effect of various parameters such as contact time, pH, adsorbent dose and concentration has been investigated in the batch experiments. The adsorption isotherms were evaluated in batch tests by using synthetic dye solution. Saturation time for both the adsorbents has been determined by conducting column studies.

2. MATERIAL AND METHODS

2.1 Materials

In the present study, two different materials were used as low-cost adsorbents. Granular activated carbon of coconut shell used in the study was procured from EnviroExtreme, Bangalore, India. The GAC was sieved and particle size of 1.18mm was used as adsorbent in the study. Coal-ash was collected from Raichur Thermal Power Plant, Raichur, India. The coal-ash was sieved and the particles of size 2.36 mm were used as an adsorbent for removal of colour. Acid orange 7, an anionic dye is used as an adsorbate for the present study. Stock solution of acid orange 7 was made using distilled water. All working solutions were prepared by diluting the stock solution with distilled water.

2.2. Batch studies

Batch experiment was carried out to measure the colour adsorption by two different adsorbents. Different adsorbent dosages were added to 100ml of synthetic dye solutions. The experiments were carried out by shaking each adsorbent of different dosages (0.5, 1 and 1.5 grams) with 100ml of dye solution of having initial concentration of 50mg/l and 100mg/l respectively. In order to mix the solution, the samples were placed in Rotary orbital shaker and samples were mixed for different contact times (5, 10, 15 and 20 min respectively) at different pH with the speed of 150 rpm. The supernatant was withdrawn and analysed for colour concentration using colorimeter at 490nm. The tests give the optimum dosage, pH and contact time. Isotherms were also developed. The pH of the synthetic sample was maintained by 0.1N HCl and 0.1N NaOH.

2.3. Column experiments

Depending on the optimum conditions obtained by batch studies for different adsorbents, column studies was performed to determine the saturation time and to obtain break-through curve. The following experimental set up has been made for the continuous removal of colour from dye solution. A column, 2.5 cm diameter and 15 cm bed height, filled with two different adsorbents was employed for this study. The column was charged with synthetic dye solution of initial 50mg/l and 100mg/l concentration and industrial wastewater. The column was run with an average flow rate of 7ml/min. Samples were collected at specific interval hours and residual dye concentration was measured using colorimeter at wavelength of 490nm. The column was operated in up-flow mode without effluent recycle.

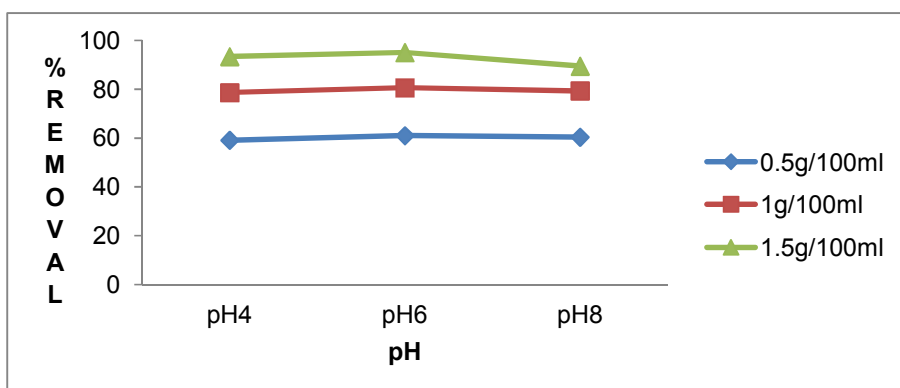
3. RESULTS AND DISCUSSION

3.1 Batch study:

3.1.1 Effect of pH:

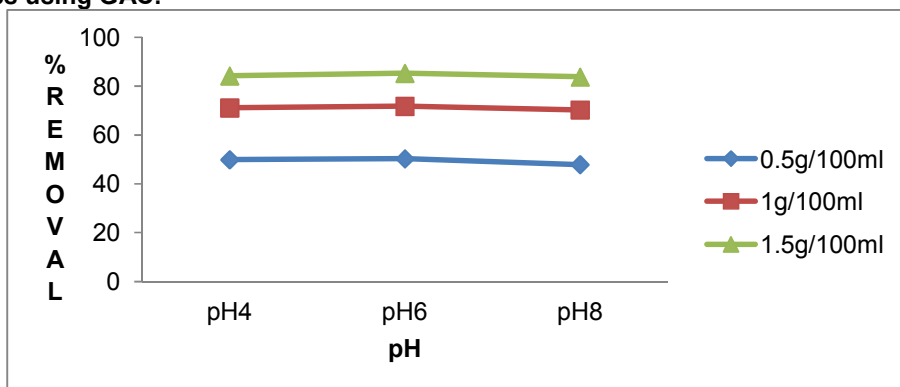
Since pH is an important controlling parameter in the adsorption process. To study the influence of pH on the adsorption capacity of GAC and Coal-ash adsorbents for colour removal, experiments were performed at room temperature, for several contact times, using various initial solution pH values 4, 6 and 8 and dye solution with initial concentrations 50 and 100 mg/l. The relation between the pH of the synthetic sample and percentage removal of colour by GAC and Coal-ash adsorbents for initial concentration of 50mg/l and 100mg/l respectively at optimum contact time of 15 minutes are shown in

Fig 1- Fig4. It is observed that there is no much influence of pH on percentage colour removal by adsorption on GAC and coal ash. Since, removal of colour was found to be almost same in all pH ranges of pH4, pH6, pH8. As the economical point of view removal of colour with less dosage and less time was found in pH6. So, pH6 was considered as optimum pH for further column study.



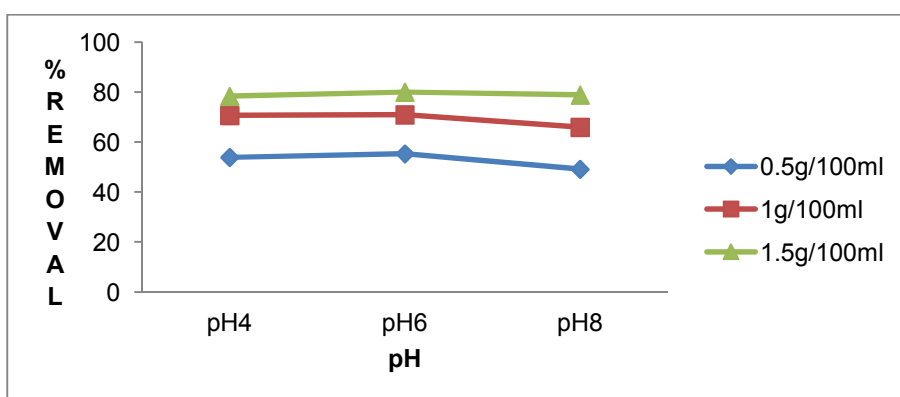
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89 **Figure 1. Effect of pH on colour removal for initial concentration of 50mg/l at contact time**
90 **15minutes using GAC.**



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92 **Figure 2. Effect of pH on colour removal for initial concentration of 100mg/l at contact time**
93 **15minutes using GAC.**



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96 **Figure 3. Effect of pH on colour removal for initial concentration of 50mg/l at contact time**
97 **15minutes using Coal ash.**

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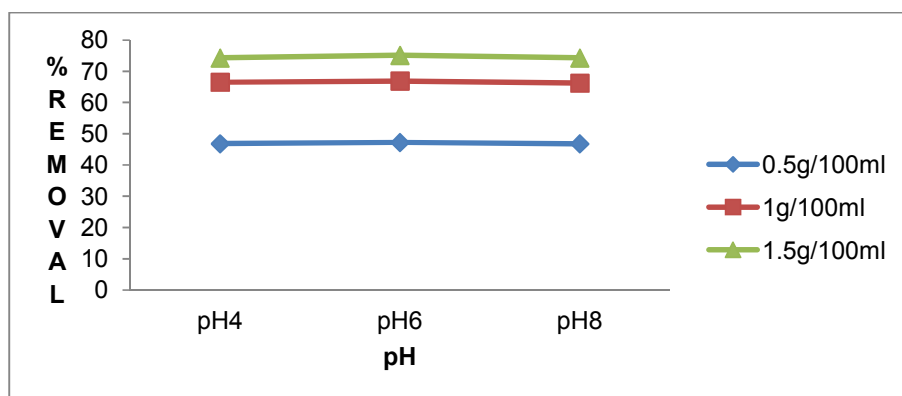


Figure 4. Effect of pH on colour removal for initial concentration of 100mg/l at contact time 15minutes using Coal ash.

3.1.2. Effect of adsorbent dose:

To investigate the effect of adsorbent dosage on colour removal onto the various adsorbent surfaces, experiments were carried out with initial dye concentration of 50 and 100 mg/l and varying adsorbent dose at room temperature and at a constant stirring speed of 150 rpm for different contact time. The results show that the percentage removal increased with increasing adsorbent dose due to the increase in the total available surface area of the adsorbent particles. Fig 5-Fig 8 shows the effect of adsorbent dosage on colour removal using GAC and Coal-ash adsorbents for initial concentration of 50mg/l and 100mg/l respectively at optimum contact time of 15 minutes for both the adsorbents.

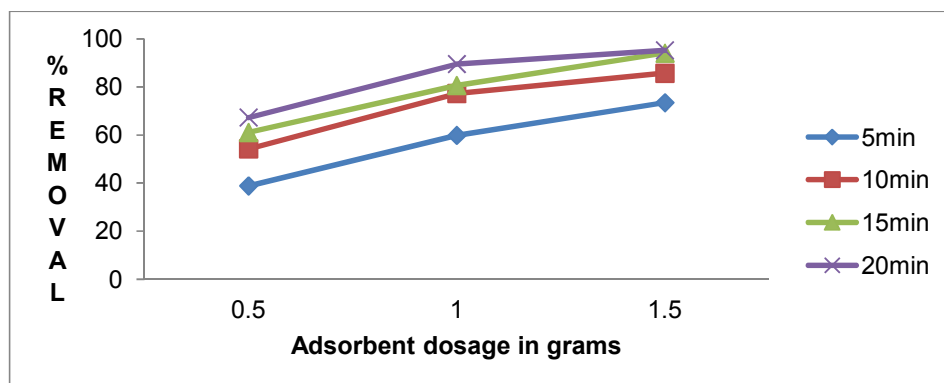


Figure 5. Effect of Adsorbent dosage on colour removal for initial concentration of 50mg/l at pH6 using GAC.

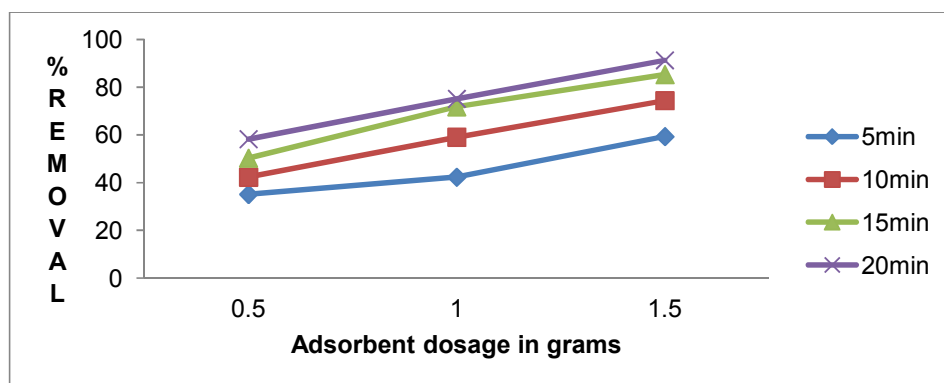


Figure 6. Effect of Adsorbent dosage on colour removal for initial concentration of 100mg/l at pH6 using GAC.

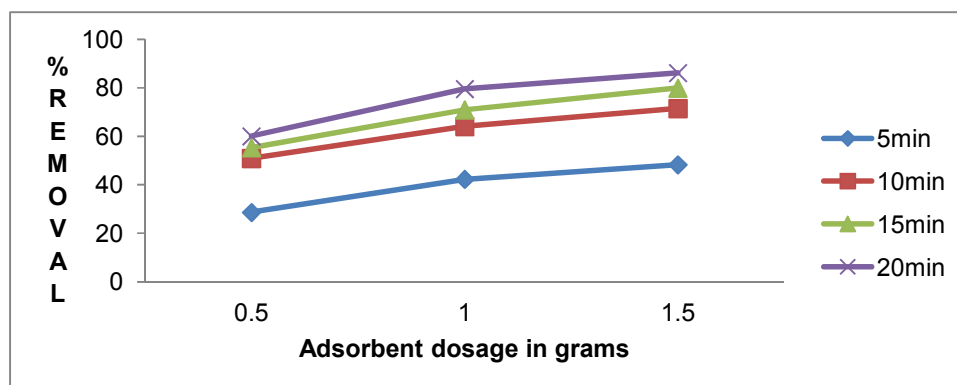


Figure 7. Effect of Adsorbent dosage on colour removal for initial concentration of 50mg/l at pH 6 using Coal ash.

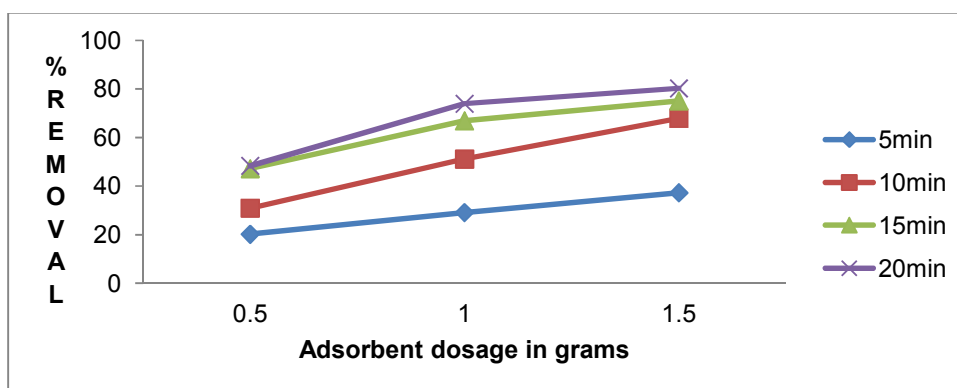


Figure 8. Effect of Adsorbent dosage on colour removal for initial concentration of 100mg/l at pH6 using Coal ash.

3.1.3 Effect of initial concentration

To investigate the effect of initial concentration on the colour adsorption, experiments were carried out with initial dye concentration of 50 and 100 mg/L and varying adsorbent dose at room temperature and at a constant stirring speed of 150 rpm for different contact time. Fig 9 and Fig 10 shows the effect of varying initial dye concentration of 50 and 100mg/L on the sorption capacity of various adsorbents. It was observed that lower initial concentration (50mg/L) resulted in higher removal efficiency compared to the higher concentration (100 mg/L). This is due to the greater relative availability of sorption sites on the adsorbent for colour removal.

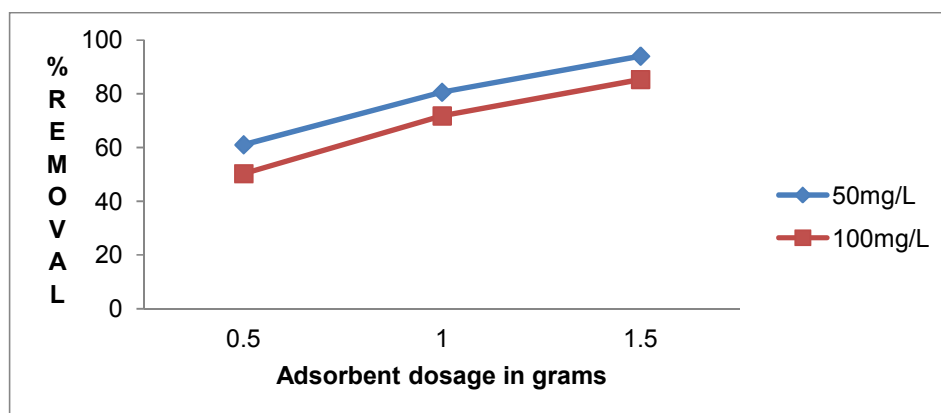


Figure 9. Effect of initial concentration on dye adsorption at optimum contact time of 15 minutes and optimum pH 6 using GAC.

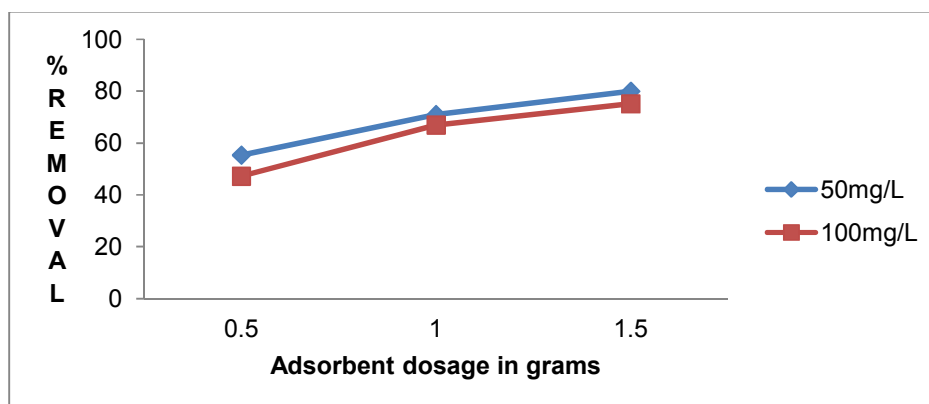


Figure 10. Effect of initial concentration on dye adsorption at optimum contact time of 15 minutes and optimum pH 6 using Coal ash.

3.2 Column study

The ratio of effluent concentration to influent concentration was plotted against the column operation time with a constant flow rate of 7ml/min. From the column break-through curve, the saturation time for GAC for synthetic sample of initial concentration 50mg/l and 100mg/L were found to be 286 and 218 hours respectively and the saturation time for Coal ash for synthetic sample of initial concentration 50mg/L and 100mg/L were found to be 145 hours and 96 hours. Both freundlich and Langmuir isotherm were plotted. Langmuir isotherm was found to be best fit for both the adsorbents. The experiments were carried out on industrial wastewater for the removal of color with the optimum operating conditions which were obtained from batch studies. Results obtained on industrial wastewater showed the results were in par with the synthetic sample.

4. CONCLUSION

The present study aimed to investigate the adsorption of acidic dye using two different adsorbents, GAC of coconut shell and Coal-ash. In batch studies, the optimum pH, effective dosage and reaction time were optimized. As a result, pH of 6, dosage of 1.5gm/100ml and contact time of 15 minutes were found to be optimized condition for the removal of acid dye by GAC of coconut shell and Coal ash. Increase in adsorbent dosage increased the percentage removal of dyes. Results from the column study showed that higher initial concentration resulted in shorter column saturation time. Adsorption isotherms were plotted for optimum conditions. Langmuir isotherm was found to be the best fit for both the adsorbents.

REFERENCES

- [1] Deepak garg. Adsorptive removal of dyes from aqueous solution using cu-btc and commercial activated carbon. B.Tech project, National Institute of Technology, Rourkela, 2012.
- [2] Sachin M.Kanawade, R.W. Gaikwad. Removal of Dyes from Dye Effluent by Using Sugarcane Bagasse Ash as an Adsorbent. International Journal of Chemical Engineering and Applications. 2012;2(3):202-206.
- [3] P. Velmurugan, V. Rathina Kumar, G. Dhinakaran. Dye removal from aqueous solution using low cost adsorbent. International Journal of Environmental Sciences. 2011;1(7):1492-1503.
- [4]M. A. Mumin, M. M. R. Khan, K. F. Akhter , M. J. Uddin. Potentiality of open burnt clay as an adsorbent for the removal of Congo red from aqueous solution. Int. J. Environ. Sci. Tech. 2007;4(4):525-532.
- [5] Ola Abdelwahab, Ahmed El Nemr, Amany El Sikaily, Azza Khaled. Use Of Rice Husk for Adsorption of Direct Dyes from Aqueous Solution: A Case Study of Direct F. Scarlet. Egyptian Journal of Aquatic Research. 2005;31(1):1110-0354.
- [6] Metcalf and Eddy. Wastewater Engineering, Treatment, Disposal and Reuse. 3rd. Ed, Mc Gray-Hill: 1991.
- [7] P.K. Malik. Use of activated carbons prepared from sawdust and rice-husk for adsorption of acid dyes: a case study of Acid Yellow 36. Science direct.2003;56:239–249.
- [8] Nevine Kamal Amin. Removal of reactive dye from aqueous solutions by adsorption on to activated carbon prepared from sugarcane bagasse pith. Elsevier Desalination. 2008;223:152-161.
- [9] O. Yavuz, A. H. Aydin. Removal of Direct Dyes from Aqueous Solution Using Various Adsorbents. Polish Journal of Environmental Studies. 2006;15(1):155-161.
- [10] Sajjala Sreedhar Reddy, Bijjam Kotaiah, Nanaga Siva Prasad Reddy. Colour Pollution Control In Textile Dyeing Industry Effluents Using Tannery Sludge Derived Activated Carbon. Chem. Soc. Ethiop. 2008;22:369-378.
- [11] Mysamy Shanker, Theivarasu Chinniagounder. Adsorption of reactive dye using low cost adsorbent: cocoa (theobroma cacao) shell. World Journal of Applied Environmental Chemistry.2012;1(1):22-29.