International Journal of Applied Chemistry.
ISSN 0973-1792 Volume 13, Number 2 (2017) pp. 341-351

http://www.ripublication.com

# Effective Removal and Recovery of Fast Green FCF Dye from Wastewater using Green Adsorbent

***Shakuntala Sawant, Kiran Lalge, Sandip Labade, Nilesh Khengre and Arvind Burungale**

*Post-Graduate Department of Chemistry and Research Centre,*
*S.M. Joshi College, Hadapsar, Pune – 28, Maharashtra, India.*
** Corresponding author*

**Abstract**

Natural wool after certain treatment converted into powdered form and have been used as adsorbent for the removal and recovery of a Fast Green FCF dye from wastewater. Batch studies have been carried by observing the effects of pH, temperature, a concentration of the dye, an amount of adsorbent, a particle size of adsorbent, contact time, etc. The adsorption over powdered wool has been found endothermic and feasible in nature. The kinetic studies suggest the process following pseudo-first-order kinetics with the rate constant 0.1957 $s^{-1}$ and involvement of particle diffusion mechanism. The bulk removal of the dye has been carried out by treatment with adsorbent followed by filtration through the syringe filter. Saturation factor for adsorbent has been calculated. Attempts have also been made to recover the dye by using dilute NaOH which results in 98- 100 % dye recovery.

**Keywords:** Powdered wool, Fast Green FCF, Adsorption, Kinetics.

## I. INTRODUCTION

It is well known that Industries producing textile, paper, rubber, plastic, leather, cosmetics, pharmaceutical and foodstuff, uses different types of dyes [1]. The discharges of these industries dispose of a huge amount of dye contents, which runs into water bodies and cause severe snags such as increasing the chemical oxygen demand (COD) and reducing light penetration and visibility, in water bodies thereby pose adverse effects on the aquatic life [2]. The presence of these dyestuffs in water bodies also makes water unfit for drinking purpose due to highly toxic effects of different types of dyes on human being [3].

Various physical, chemical, and biological methods like, coagulation and flocculation, oxidation or ozonation, membrane separation, ultrafiltration, chemical treatments, activated carbon adsorption, photocatalytic degradation, bacterial degradation etc. have been used for the dye removal and degradation [4-14]. But they are either quite expensive or cannot be applied to large volumes of water [15]. Thus in recent time, alternative methods for the removal of dyes from wastewaters with the use of various low-cost adsorbents is in high demand. Some low-cost adsorbents such as baggase fly ash [16], wool [17], fertilizer waste [18], shale oil ash [19], rice husk [20], fruit stones [21], red mud [22], etc. have been used by various workers. The biggest advantage of the use of physically modified wool as adsorbents is their low cost, versatility, and easy operations [23]. In recent years many research groups [24–29] were contributed some important and useful research publications on the dye removal by various materials in search of sustainable process.

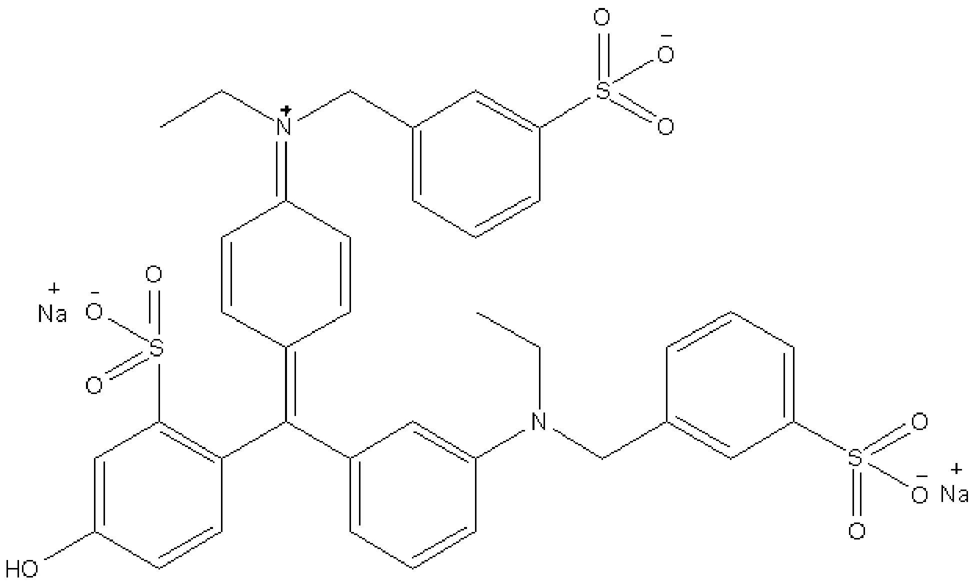


**Fig. 1.** Chemical structure of Fast Green FCF.

The sea green triaryl methane food dye Fast Green FCF (Fig. 1) (C.I.No. 42053) is also known as Food Green 3, FD and C Green No. 3, Green 1724 and Solid Green FCF with absorption maximum ranging from 622 to 626 nm, Fast Green FCF has a brilliant blue-green colour, which is less likely to die away [30]. It is widely used as a staining agent like quantitative stain for histones at alkaline-Hafter acid extraction of DNA, as a protein stain in electrophoresis. It is recommended as a replacement of many other stains such as Light Green SF Yellowish in Masson's trichome (a staining protocol used in histology) [31]. Toxicological data divulge that Fast Green FCF is highly toxic [32]. It is an allergen to the humans and may cause eye, skin, and the upper respiratory tract irritation. It also acts as a presynaptic locus by hindering the release of neurotransmitters in the nervous system [33]. It is known carcinogen and able to induce sarcomas at the site of frequent hypodermic injection [34,35]. For a long time Fast Green FCF was used for coloring the foodstuffs, however looking in view of its toxicity results the European Union and many other countries have prohibited its edible use [36].

Present work is an attempt to develop a sustainable sorbent material with modified powdered wool for the removal of Fast Green FCF from effluent.

## II. MATERIALS AND METHOD

Fast Green FCF (4,4_-bis-(*N*-(ethyl-3-sulphobenzyl)-amino-2-sulpho-4-hydroxy-fuchsonlum, disodium salt), (Molecular formula $C_{37}H_{34}N_2O_{10}S_3Na_2$ and molecular weight 808.85) was purchased from Otto chemicals. A stock solution was prepared in distilled water. Wool was obtained from a single ship owned by a local shepherd. The pH measurements were done using a microprocessor based pH meter model LI 120 (Elico Instruments, India) and absorption studies were carried out on UV–Vis spectrophotometer model number UV- 2700 (Shimadzu Inc. Japan). IR spectra were recorded on IR Tracer Afinity FTIR spectrophotometer (Shimadzu Inc. Japan)

### *2.1. Material development*

In the first stage, wool was carbonized using sodium carbonate and hydrochloric acid. Washed with distilled water. Wool then cut into small pieces and powdered which is used as adsorbent in further studies. Finally, the adsorbent was sieved to various mesh sizes viz. 125, 150 and 180 BSS mesh and stored separately in desiccators.

### *2.2. Adsorption studies*

Batch studies were performed taking 25 mL of the dye solution of known concentration in 100 mL volumetric flask at 25 ◦C and definite pH. Desired mesh sizes for the adsorbent materials were selected and studies were carried out by changing the adsorbent dosage, concentration of adsorbate, pH of solution, contact time, etc. After certain time these solutions were filtered with porafil syringe filter (0.22 μ) and the amount of the dye uptake was analyzed spectrophotometrically at $\lambda_{max}$ 622 nm.

### *2.3. Dye Recovery studies*

Dye solution of $5\times10^{-4}$ M concentration of Fast Green FCF was then shaken with appropriate adsorbent dose till a colorless solution is obtained. The dye adsorbed on the adsorbent was treated with NaOH (pH 10) for desorption and filtered. The amount of dye recover in solution was analyzed spectrophotometrically at λ max 622 nm.

## III. RESULTS AND DISCUSSION

### *3.1. Characterization of adsorbents*

Chemical analysis of powdered wool before and after adsorption was carried out by using conventional spectroscopic method and available analytical techniques (Figs. 2).

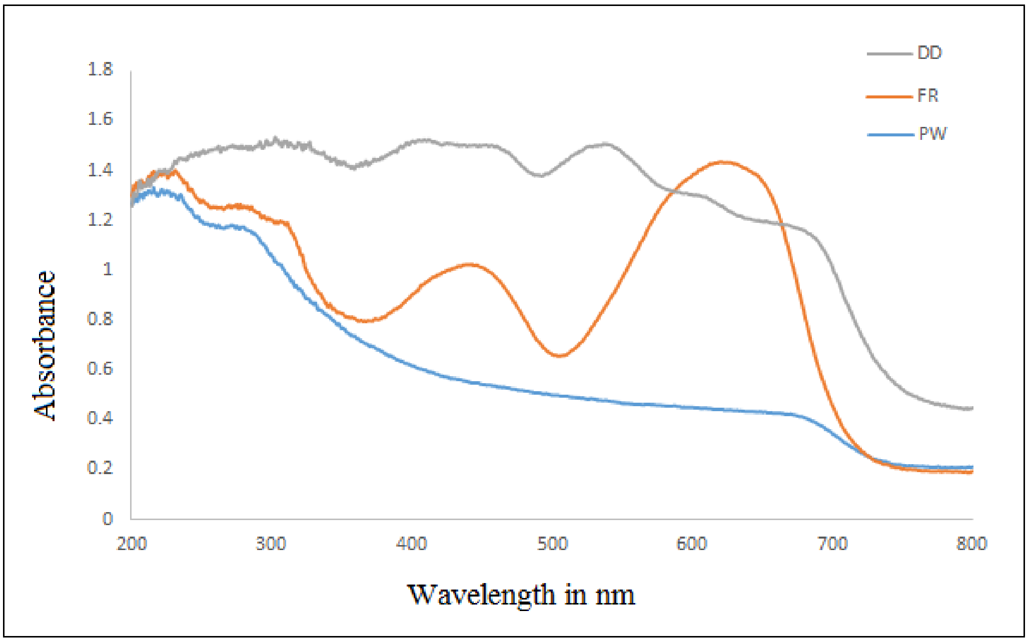


**Fig. 2.** Diffuse reflectance Spectra, DD:Fast Green FCF, PW: Powdered wool, FR: Fast

### *3.2. Adsorption studies*

#### *3.2.1. Effect of pH*

The effect of pH on the adsorption of the dye was studied in the pH range of 1.0–10.0 for powdered wool. With the increase in pH, adsorption was found to decrease till pH 4 in each case **(Fig. 3)** and after pH 4, no significant variance in the quantity of dye adsorption was detected on proceeding further till pH 10. The decline in adsorption by increasing pH can be elucidated on the basis of protonation and deprotonation of dye molecule as well as sorbent. Protonation of the anionic dye takes place on the addition of acid which allows significant affinity towards the negatively charged adsorbents. On increasing the pH, deprotonation of the dye takes place, which thereby declines the amount of dye. adsorbed.pH 2 has been chosen for the studies on account of the fact that the amount adsorbed in this case is maximum.

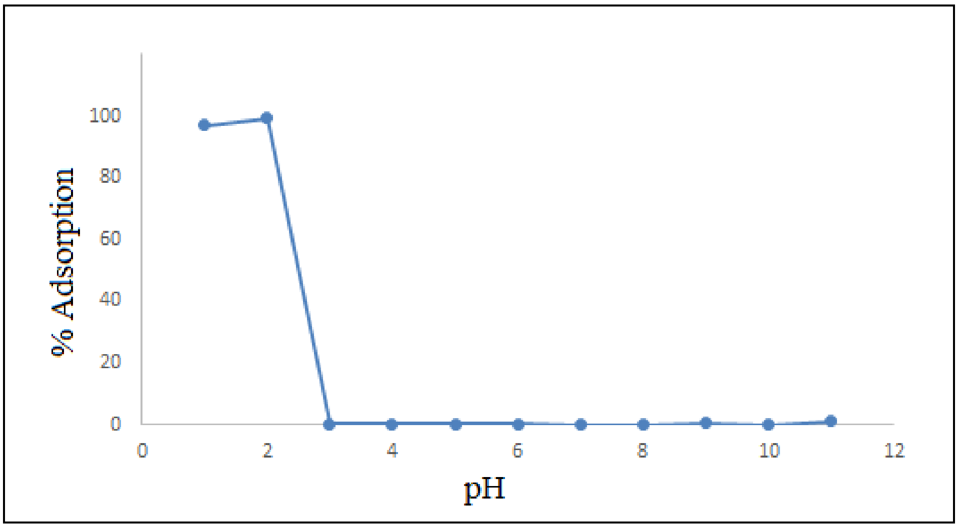


**Fig. 3.** Effect of pH of dye solution on adsorption at 25°C and 1.25 x $10^{-4}$ M dye concentration. adsorbent dose 200 mg/25 ml, Particle size 125-150 mesh.

### *3.2.2. Effect of amount of adsorbents*

In order to study the variation in adsorption on the basis of amount of the adsorbent materials, various amounts (0.05 g – 0.250 g) of powdered wool was taken and study was made at 25°C and 1.25 x $10^{-4}$ M dye concentration and pH=2. It is found that the uptake capacity of the dye increases with increase in the amount of adsorbent **(Fig. 4)**.

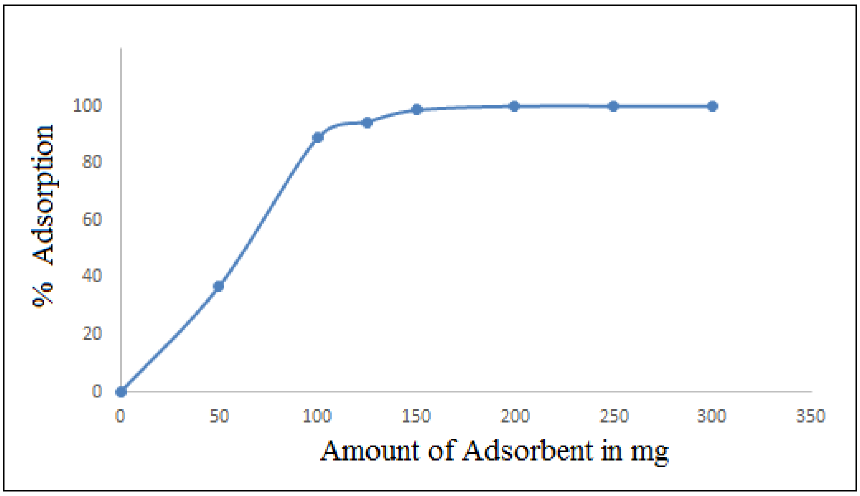


**Fig. 4.** Effect of amount of Adsorbent on adsorption at 25°C, 1.25 x $10^{-4}$ M dye concentration and pH=2

*3.2.3. Effect of particle size*

For batch adsorption experiments, three different particle sizes viz. 36, 100 and 170 BSS mesh were selected difference in the amount adsorbed was noticed with the increase in mesh size. **(Fig. 5)**presents effect of sieve size of adsorbents on the adsorption at 25°C. Adsorption was found to increase with the decrease in the mesh sizes. This is due to increase in the surface area of the adsorbents and accessibility of the active functional groups towards the dye.

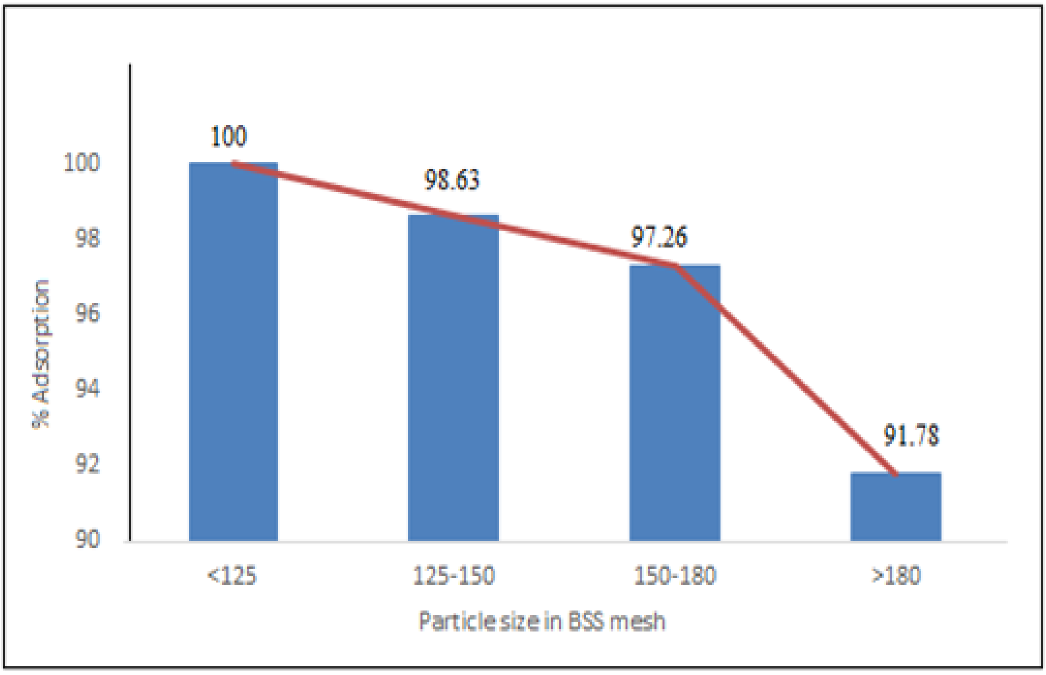


**Fig. 5.** Effect of particle size of Adsorbent on adsorption at 25°C, 1.25 x $10^{-4}$ M dye concentration and pH=2, Adsorbent dose 200 mg/25 ml

*3.2.4. Effect of concentration*

For the study of effect of concentrationaqueous solutions of Fast Green FCF was investigated for the dye removal with fixed amount of adsorbent dose at 25°C. Experiments reflect that increase in concentration of Fast Green FCF increases the extent of adsorption in case of powdered wool (Fig. 6).

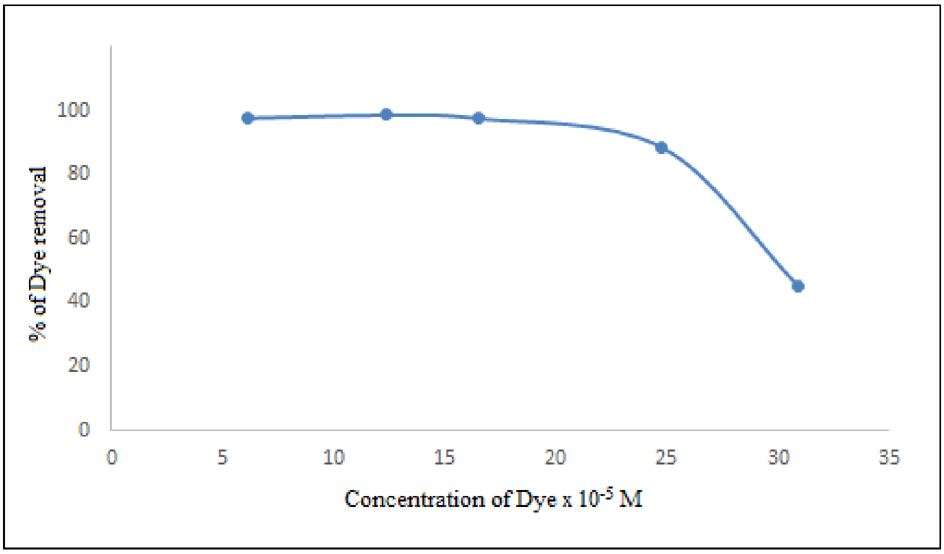


**Fig. 6.** Effect of concentration of Dye on adsorption at 25°C, and pH=2, Adsorbent dose 200 mg/25 ml

### *3.2.5. Effect of contact time*

With the increase in time the adsorption increases for powdered wool. The percentage adsorption of the dye during the first 20 secondsof contact was almost 98 – 100 %. From experimental data, it is found that this adsorption follows pseudo first-order kinetics Half-life of the process were also calculated and found as 3.54 seconds These results also confirm the endothermic nature of the adsorption.(**Fig. 7)**

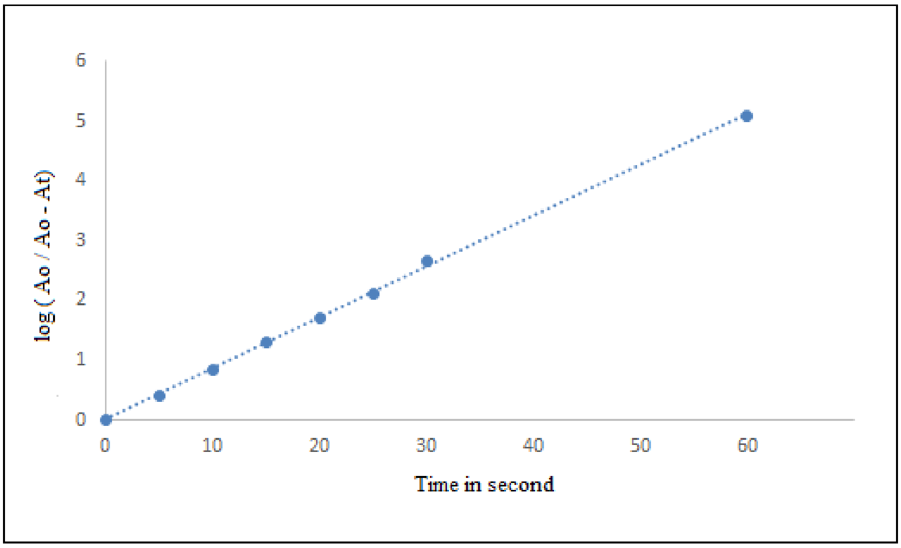


**Fig. 7.** Effect of contact time on adsorption at 25°C, and pH=2, Adsorbent dose 200 mg/25 ml

### *3.3. Dye recovery*

In order to recover the adsorbed dye, NaOH solution of pH 10 was employed. Dye loaded powdered wool was stirred with NaOH solution for 1 min. For complete desorption of Fast Green FCF 20 mL of NaOH was required per gram of dye loaded adsorbent. The percentage recovery of the dye95%

## IV. CONCLUSION

Studies clearly reveal that powdered wool can be effectively used for the removal of Fast Green FCF from wastewaters. The adsorption process of Fast Green FCF over the adsorbents has been found spontaneous and feasible and chemisorption has been found to be operative. The adsorption of the dye over both the materials follows pseudo first-order kinetics with $k$ values ranging from 0.1957 $s^{-1}$. On the basis of mass transfer studies, it is also concluded that transportation of the dye towards adsorbent materials is rapid exhibit good affinity towards the dye. Bulk removal of the dye is been carried out and percentage 98 – 100 %, respectively. The dye recovery is made by NaOH of pH 10 and as per spectrophotometric estimation, about 98% of the dye is recovered from powdered wool.

## ACKNOWLEDGEMENTS

Authors are thankful to Principal, S. M. Joshi College, for providing an opportunity for the said research work.

## REFERENCES

[1] B.E. Reed, M.R. Matsumoto, J.N. Jensen, R. Viadero, W. Lin, 1998, Physico-chemical processes, Water Environ. Res.,70 (4),pp. 449–473.

[2] C.A.Murray, S.A. Parsons, 2004, Advanced oxidation processes: flowsheet options for bulk natural organic matter removal, Water Sci. Technol.: Water Supply, 4, pp. 113–119.

[3] Alok Mittal, Dipika Kaur, Jyoti Mitta,2009,Batch and bulk removal of a triaryl methane dye, Fast Green FCF, from wastewater by adsorption over waste materials, Journal of Hazardous Materials, 163,pp. 568–577

[4] S.A. Parsons, B. Jeffersons,2006, Introduction to Potable Water Treatment Process, Blackwell Publishing, p. 145.

[5] D. Brown, B. Hamburger, 1987, The degradation of dyestuffs: Part III—Investigations of their ultimate degradability, Chemosphere, 16 (7), pp. 1539–1553.

[6] H.-Y. Shu, C.-R. Huang, M.-C. Chang, 1994, Decolorization of mono-azo dyes in wastewater by advanced oxidation process: a case study of Acid Red 1 and Acid Yellow 23, Chemosphere, 29 (12), pp. 2597–2607.

[7] H.-Y. Shu, C.-R. Huang, 1995, Degradation of commercial azo dyes in water using ozonation and UV enhanced ozonation process, Chemosphere 31 (8),pp. 3813.

[8] A. Gurses, C¸ .Do˘gar, M. Yalc¸ ın, M. Ac¸ ıkyıldız, R. Bayrak, S. Karaca, 2006, The adsorption kinetics of the cationic dye, methylene blue, onto clay, J. Hazard. Mater. , 131, pp. 217–228.

[9] C. Allegre, P. Moulin, M. Maisseu, F. Charbit, 2006, Treatment, and reuse of reactive dyeing effluents, J. Membr. Sci. 269, pp. 15–34.

[10] U. Pagga, K. Taeger, 1994, Development of a method for adsorption of dyestuffs on activated sludge, Water Res. 28 (5), pp. 1051–1057.

[11] K. Santhy, P. Selvapathy,2006, Removal of reactive dyes from wastewater by adsorption on coir pith activated carbon, Bioresour. Technol.,97,pp.1329–1336.

[12] T. Robinson, B. Chandran, P. Nigam, 2002, Studies on desorption of individual textile dyes and a synthetic dye effluent from dye-adsorbed agricultural residues using solvents, Bioresour. Technol., 84, pp. 299–301.

[13] L.G. Devi, R. Kavitha, 2013, A review on nonmetal ion doped titania for the photocatalytic degradation of organic pollutants under UV/solar light: Role of photogenerated charge carrier dynamics in enhancing the activity, Applied Catalysis B, Environmental, 140, pp. 559-587

[14] Miguel Pelaez et.al. 2012, A review on the visible light active titanium dioxide photocatalysts for environmental applications, Applied Catalysis B: Environmental,125, pp. 331–349

[15] Thai Anh Nguyen, Chun-Chieh Fu, Ruey-Shin Juang, (2016, Biosorption and biodegradation of a sulfur dye in high-strength dyeing wastewater by Acidithiobacillusthiooxidans, Journal of Environmental Management, 182, pp. 265 - 271

[16] V.K. Gupta, I. Ali, 2001, Removal of DDD and DDDE from waste water using bagasse fly-ash–sugar industry waste, Water Res., 35 (1), pp. 33–40.

[17] A. Atef El-Sayed, M. Salama, M. H. El-Rafie&Hossam E. Emam, 2016, Modified Rice Straw as a Template in Syntheses of Nano TiO2 Loaded on Wool Fibers for Wastewater Treatment, Journal of Natural Fibers,13, pp. 1-13

[18] S.K. Shrivastava, R. Tyagi, 1995, Competitive adsorption of substituted phenols by activated carbon developed from fertilizer waste slurry, WaterRes.,29 (2), pp. 483–488.

[19] Z. Al-Qodah, 2000, Adsorption of dyes using shale oil ash, Water Res., 34 (17), pp. 4295–4303.

[20] K. Srinivasan, N. Balasubramanian, T.V. Ramakrishna, 1988, Studies of chromium removal by rice husk carbon, Indian J. Environ. Health, 30,pp. 376–387.

[21] S.H. Gharaibeh, W.Y. Abu-el-Shar, M.M. Al-Kofahi, 1998, Removal of selected heavy metals from aqueous solutions using processed solid residue of olive mill products, Water Res., 32 (2), pp. 498–502.

[22] V.K. Gupta, M. Gupta, S. Sharma, 2001, Process development for the removal of lead and chromium from aqueous solutions using red mud—an aluminum industry waste, Water Res., 35 (5), pp. 1125–1134.

[23] Vadim Volkov, ArturCavaco-Paulo, 2016, Enzymatic phosphorylation of hair keratin enhances fast adsorption of cationic moieties, International Journal of Biological Macromolecules, 85, pp. 476–486.

[24] XiongShuiying, QiuMuqing, Song Jiangping, Wang Gusheng, Xuan Yannan, 2016,Adsorption Isotherm and Equilibrium Process of Dye Wastewater onto Camphor Sawdust, Nature Environment and Pollution Technology, 15(2), pp. 689-692.

[25] Marilice S. Bretanha, Guilherme L. Dotto, Julio C.P. Vaghetti, Silvio L.P. Dias, Eder C. Lima & Flavio A. Pavan, 2016, Giombo persimmon seed (GPS) an alternative adsorbent for the removal Toluidine Blue dye from aqueous solutions, 1, pp. 1–12

[26] Shilpi Agarwal , HamidrezaSadegh , Majid Monajjemi , Abdel Salam Hamdy, Gomaa A.M. Ali, Amir O.H. Memar , RaminShahryari-ghoshekand, InderjeetTyagi, Vinod Kumar Gupta, 2016, Efficient removal of toxic bromothymol blue and methylene blue from wastewater by polyvinyl alcohol, Journal of Molecular Liquids, 218, pp. 191–197

[27] Claire Xin-Hui Su, Ling Wei Low, Tjoon Tow Teng, Yee Shian Wong, 2016,Combination and hybridization of treatments in dye wastewater treatment: A review, Journal of Environmental Chemical Engineering, 4(3),pp. 3618–3631

[28] Zhongzhu Yang, Fenghua Wang, Chang Zhang, Guangming Zeng, Xiaofei Tan, Zhigang Yu, Yu Zhong, Hou Wang and Fang Cui, 2016, Utilization of LDH-based materials as potential adsorbents and photocatalysts for the decontamination of dyes wastewater: a review, RSC Adv., 6 ,pp. 79415 – 79436

[29] Gabriella Alexandre Borges, Luciana Pereira Silva , Jussara Alves Penido, Leandro Rodrigues de Lemos, Aparecida Barbosa Mageste, Guilherme Dias Rodrigues, 2016, A method for dye extraction using an aqueous two-phase system: Effect of co-occurrence of contaminants in textile industry wastewater, Journal of Environmental Management, 183(1), pp. 1-8.

[30] Triphenylmethane and related dyes Kirk-OthmerEncyclopedia of Chemical Technology, 1993, vol. 24, Fourth Edition, John Wiley & Sons, Inc., New York.

[31] Triarylmethanecoloring matters, in: The Colour Index International, CD-ROM, Third Edition, The Society ofDyers and Colourists and The American Association of Textile Chemists and Colorists, p. 4379.

[32] M.A. Ali, S.A. Bashier, 2006, Effect of fast green dye on some biophysical properties of thymocytes and splenocytes of albino mice, Food Additives Contaminants 23, pp. 452–461.

[33] J.A. Van Hooft, 2002, Fast Green FCF (Food Green 3) inhibits synaptic activity in rat hippocampal interneurons, Neurosci. Lett. 318 (3), pp. 163–165.

[34] Ashok Kumar Giri, Tara Shankar Banerjee, GeetaTalukder, Archana Sharma, 1986, Effects of dyes (Indigo Carmine, Metanil Yellow, Fast Green FCF) and nitrite in vivo on bone marrow chromosomes of mice,Cancer Letters, 30, pp. 315-320

[35] Yu F. Sasaki, Satomi Kawaguchi, Asako Kamaya, Miyuki Ohshita, Kazumi Kabasawa, Kayoko Iwama, Kazuyuki Taniguchi, Shuji Tsuda, 2002, The comet assay with 8 mouse organs: results with 39 currently used food additives, Mutation Research 519,pp. 103–119

[36] “Food Dyes” Colour Index, 1971,Third Edition, The Society of Dyers and Colourists and the American Association of Textile Chemists and Colorists.