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COMPARATIVE STUDY OF SINGLE AND MIXTURE OF ADSORBENTS ON EFFICIENCY OF ADSORPTION

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Abstract

Dyes are coloured compounds which are widely used in textiles, printing, rubber, cosmetics**,** plastics, leather industries to colour their products resulting in a large amount of coloured wastewater. Decolourization of waste water from textile and manufacturing industries is a major challenge for environmental managers as dyes are water soluble and produce very bright colours in water with acidic properties. This research attempts to compare the efficiencies of single and mixtures of adsorbents (*Citrullus lanatus* Peel, *Citrullus lanatus* Rind *and Citrus limetta* Peel) in decolourizing Crystal Violet and Brilliant Green dyes. Single adsorbent *Citrus limetta* Peel is effective in decolourizing Crystal Violet and Brilliant Green dyes at 50 mg/L to 94.72% and 57.29% respectively. Also *Citrullus lanatus* Rind decolourizes Crystal Violet dye to 52.48% at 50mg/L. Mixture of adsorbents *Citrullus lanatus* Peel + *Citrus limetta* Peel are effective in decolourizing both Crystal Violet and Brilliant Green dyes at 50 mg/L to 42.55% and 67.71% respectively and *Citrullus lanatus* Rind + *Citrus limetta* Peel can decolourize Crystal Violet and Brilliant Green dyes at 125 mg/L to 64.47% and 46.63% respectively. *Citrullus lanatus* Peel + *Citrullus lanatus* Rind can remove 41.61% of Crystal Violet dye at 50 mg/L and 58.69% of Brilliant Green dye at 125 mg/L.

Introduction

The synthetic dyes are chemical compounds which attach themselves to fabrics or surface shells to impart colour and create havoc in the environment as these persist in the environment, difficult to degrade due to their complex aromatic structures, pollute the water bodies and affect aquatic life and enter into food webs and have carcinogenic and mutagenic effects (Vinoth *et al*., 2010; Abbas *et al*., 2011; Karthik *et al*., 2012). Majority of these dyes are azo dyes which are bright in colour due to the presence of one or several azo (–N=N–) groups associated with substituted aromatic structures (Vinoth *et al*., 2010). Amongst several physical techniques, adsorption is an efficient, effective and best equilibrium process for the removal of colour from the wastewater (Sharma *et al*., 2005; Karthik *et al*., 2012). Adsorption technique employing solid activated carbon is widely used to remove colour and pollutants from wastewater. However, it is costly and the modern focus is on natural adsorbents. This research is aimed at studying waste natural adsorbents Watermelon (*Citrullus lanatus*) Peel and Rind and Musambi (*Citrus limetta*) Peel and their mixtures to compare the efficiencies in decolourizing two synthetic dyes (Crystal Violet (CV) and Brilliant Green (BG)).

2. Materials and Methodology

2.1 Preparation of Adsorbent

Waste *Citrullus lanatus* Peel and *Citrus limetta* Peel are collected from Sir MVIT canteen and are washed with distilled water. The *Citrullus lanatus* Rind is removed from the Peel and all these are allowed to dry under the sun till these have became crisp and easy to be crushed. These are then powdered in mixer separately. These are then passed through a 0.246 mm sieve to obtain uniform particle size of adsorbents. The size of the sieve is chosen according to the study by Abdul Karim *et al.*, 2015. The adsorbents are then stored in air tight containers.

2.2 Preparation of Adsorbate

A stock solution of 0.5 g/L of two different dyes (Crystal Violet (CV) and Brilliant Green (BG)) are prepared separately and stored in different volumetric flasks.

2.3 Batch Studies

Aliquots of the dyes are prepared to obtain solutions with concentrations 50 – 125 mg/L. The volume is made to 100 mL. These dyes are taken in 250 mL conical flasks and 0.5g of *Citrullus lanatus* Peel, *Citrus limetta* Peel and *Citrullus lanatus* Rind adsorbent is weighed separately and added to each conical flask. The solutions are agitated at a constant room temperature of 33^0C and speed of 240 wrist action per minute using Secor India Griffin Flask Shaker for 60 minutes. The adsorbate is filtered out using ordinary filter paper from each of the conical flasks in order to get a clear solution. Optical Density is taken at 650 nm and 550 nm for CV and BG dyes respectively using Systronics Spectrophotometer (Model-106). The process is repeated for all the adsorbents. For mixture of adsorbents 0.5 gm each adsorbent is mixed to get 1 gm and these are added to dyes and same procedures are followed.

The percentage removal of adsorbate adsorbed on the adsorbent is calculated as

$$\%Dye\,\mathrm{Re}moval = \frac{(C_0 - C_f)}{C_0} * 100 \text{----------(1)}$$

Where C_0 = Initial Concentration of Dye (mg/L)

C_f = Final Concentration of Dye after Adsorption (mg/L)

Overall change in percentage of dye removal is calculated as

$$Overall\%Dye\,\mathrm{Re}moval = \frac{(\%IDR - \%FDR)}{\%IDR} * 100 \text{----------(2)}$$

Where $\%IDR$ = Percentage of Initial Dye Removal

$\%FDR$ = Percentage of Final Dye Removal

3. Results and Discussion

From Figure 1 it is seen that percentage dye removal for Crystal Violet dye at initial concentration of 50 mg/L using single adsorbents is found to be 52.48% with *Citrullus lanatus* Rind and 94.72% with *Citrus limetta* Peel and at final concentration of 125 mg/L percentage dye removal decreased to 13.04% with *Citrullus lanatus* Rind and 44.47% with *Citrus limetta* Peel. There is a 75.15% and 53.05% overall decrease in percentage dye removal with *Citrullus lanatus* Rind and *Citrus limetta* Peel respectively. This can be attributed to the presence of active sites on the adsorbent leading to interaction of dyes with the surface of adsorbent and this interaction decreases as active sites on adsorbent are occupied with increasing dye concentration. The results are in accordance with previous studies (Rosemal *et al.,* 2010; Karthik *et al.,* 2012; Basu *et al*., 2017). However, slight increasing trend is observed for percentage dye removal with *Citrullus lanatus* Peel (Figure 1). With 50 mg/L initial concentration, the percentage dye removal for CV dye is found to be 49.07% which has increased to 56.65% at 125 mg/L, an overall increase of 15.45%. This is because the adsorbed dye molecules tend to increase adsorption of other molecules. Also the dye molecules have to encounter the boundary layer effect before diffusing from boundary layer film onto adsorbent surface and then its diffusion into porous structure of adsorbent. This is similar to the work done by (Vinoth *et al.,* 2010). Figure 2 shows the percentage dye removal of Brilliant Green dye with single adsorbents. At initial concentration of 50 mg/L, the percentage dye removal is very low at 4.58% with *Citrullus lanatus* Rind, 65.83% with *Citrullus lanatus* Peel and 57.29% with *Citrus limetta* Peel. At final concentration of 125 mg/L percentage dye removal is found to decrease slightly at 3.27% with *Citrullus lanatus* Rind and 64.52% with *Citrullus lanatus* Peel. With *Citrus limetta* Peel, the percentage dye removal is found to decrease at 30.77% which shows an overall decrease of 46.29%.

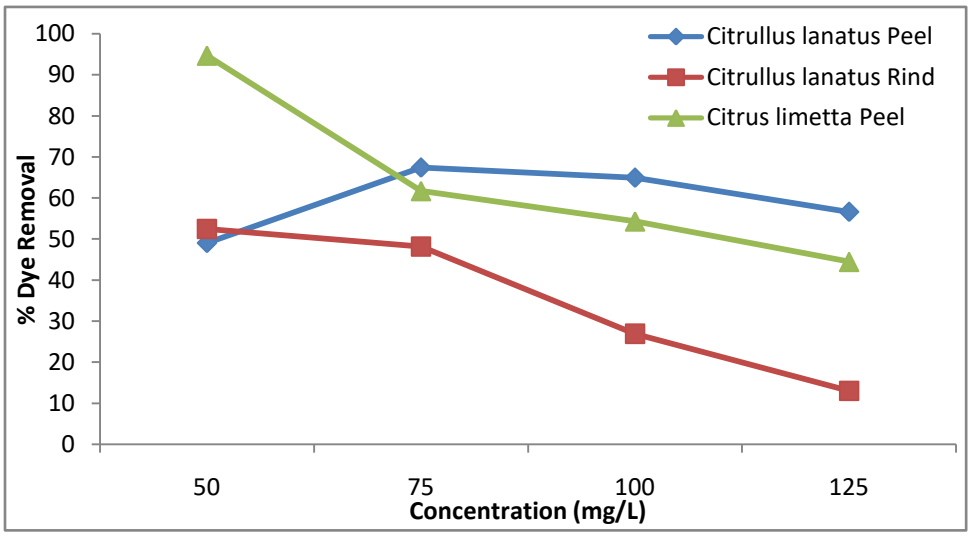

Figure 1 Percentage Dye Removal of Crystal Violet Dye with Single Adsorbents at Adsorbent Dose of 0.5 gm and size 0.246 mm

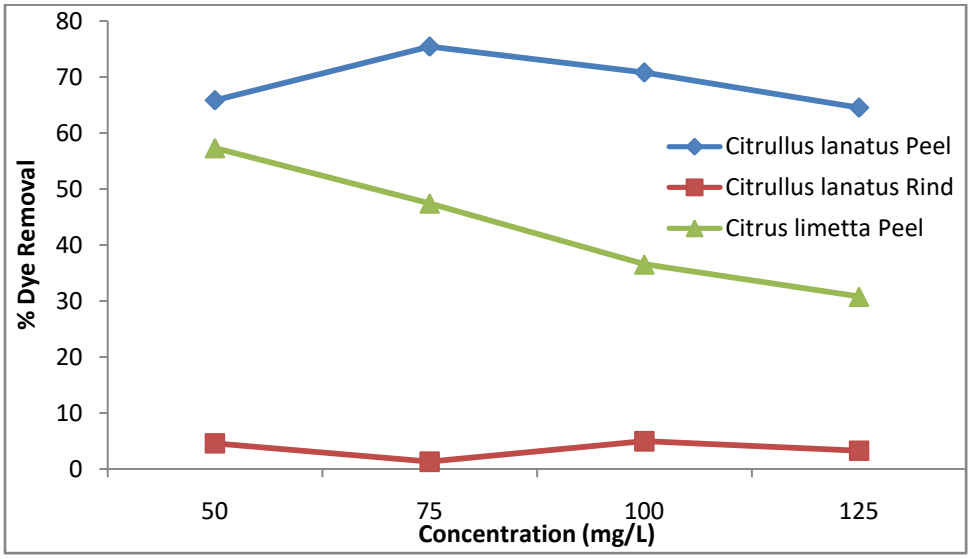

Figure 2 Percentage Dye Removal of Brilliant Green Dye with Single Adsorbents at Adsorbent Dose of 0.5 gm and size 0.246 mm

Figure 3 shows the overall changes in percentage of dye removal from initial to final concentration of dyes with single adsorbents. There has been 75.15% and 53.05% decline in dye removal efficiency of CV dye with *Citrullus lanatus* Rind and *Citrus limetta* Peel respectively while there is a 15.45% rise with *Citrullus lanatus* Peel. Similar trend is observed with BG dye and there is 28.6% and 46.29% decline in dye removal efficiency of BG dye with *Citrullus lanatus* Rind and *Citrus limetta* Peel respectively while there is a marginal 1.99% decline with *Citrullus lanatus* Peel. This study shows that *Citrullus lanatus* Rind is effective in decolourizing CV dye at concentration of 50 mg/L. *Citrus limetta* Peel is very effective in decolourizing CV dye and also can decolourize BG dye significantly at concentration of 50 mg/L. *Citrullus lanatus* Peel is effective in decolourizing CV and BG dyes at 50 mg/L and also 125 mg/L.

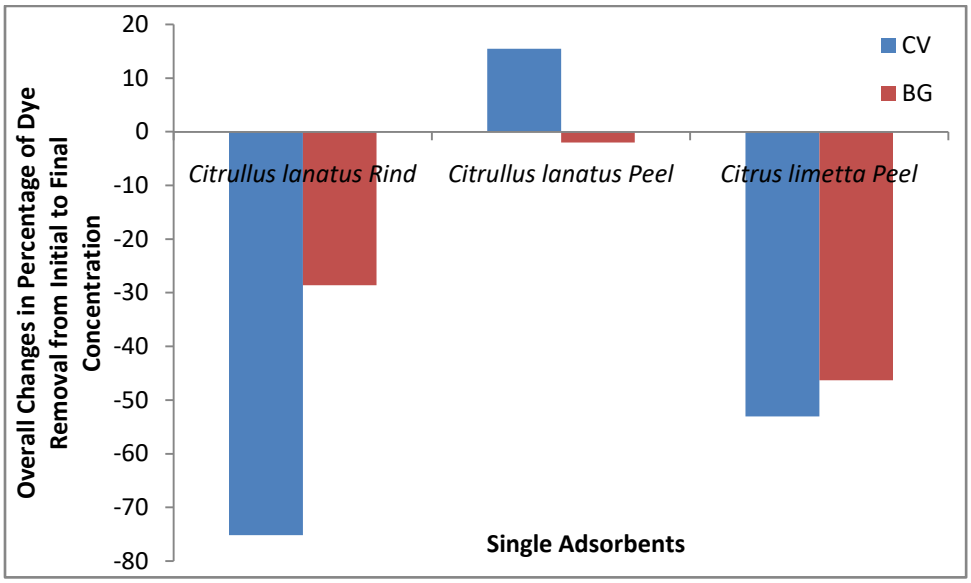

Figure 3 Overall Changes in Percentage of Dye Removal from Initial to Final Concentration of Dyes with Single Adsorbents

Figures 4 and 5 give the percentage dye removal of CV and BG dyes with mixture of adsorbents. Figure 4 shows that the mixture of adsorbents *Citrullus lanatus* Peel + *Citrus limetta* Peel and *Citrullus lanatus* Peel + Rind are effective in decolourizing CV dye at 50 mg/L with percentage dye removal at 42.55% and 41.61% respectively, but the percentage dye removal declines at 125 mg/L at 26.34% and 37.64% respectively. Similarly from Figure 5, the mixture of *Citrullus lanatus* Peel + *Citrus limetta* Peel can decolourize BG dye effectively at 50 mg/L with percentage dye removal at 67.71% which decreases to 42.23% at concentration of 125 mg/L. However, the mixture of *Citrus limetta* Peel + *Citrullus lanatus* Rind can decolourize CV dye to only 17.08% at 50 mg/L but is very efficient at 125 mg/L and can remove 64.47% of CV dye, with overall rise of 277.46%. Similar trend is seen with BG dye (Figure 5) where this mixture of *Citrus limetta* Peel + *Citrullus lanatus* Rind is found to remove 29.17% at 50 mg/L concentration of dye which increases to 46.63% at 125 mg/L, with overall increase of 59.86%. However, the mixture of *Citrullus lanatus* Peel + Rind can remove 38.33% of BG dye at 50 mg/L but the efficiency has increased to 58.69% at dye concentration of 125 mg/L.

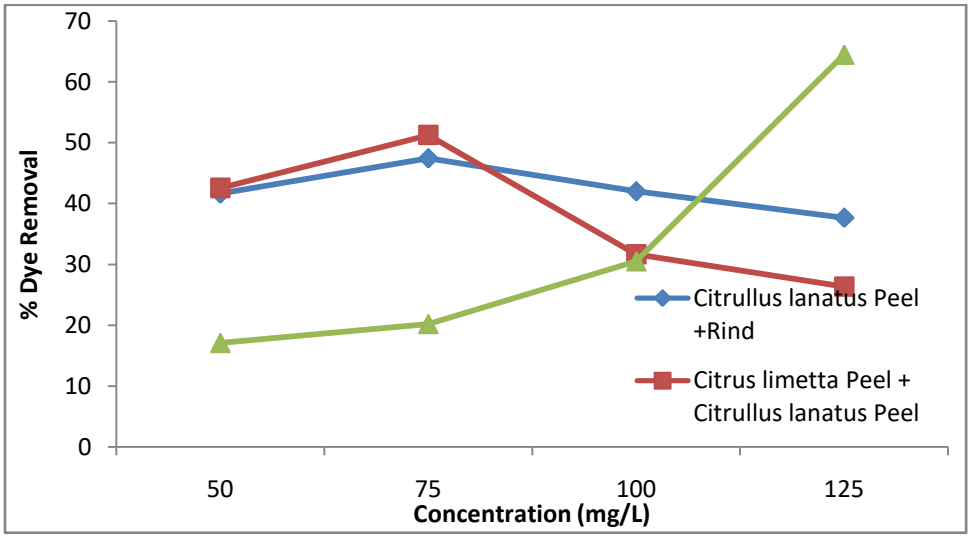

Figure 4 Percentage Dye Removal of Crystal Violet Dye with Mixture of Adsorbents at Adsorbent Dose of 1 gm and size 0.246 mm

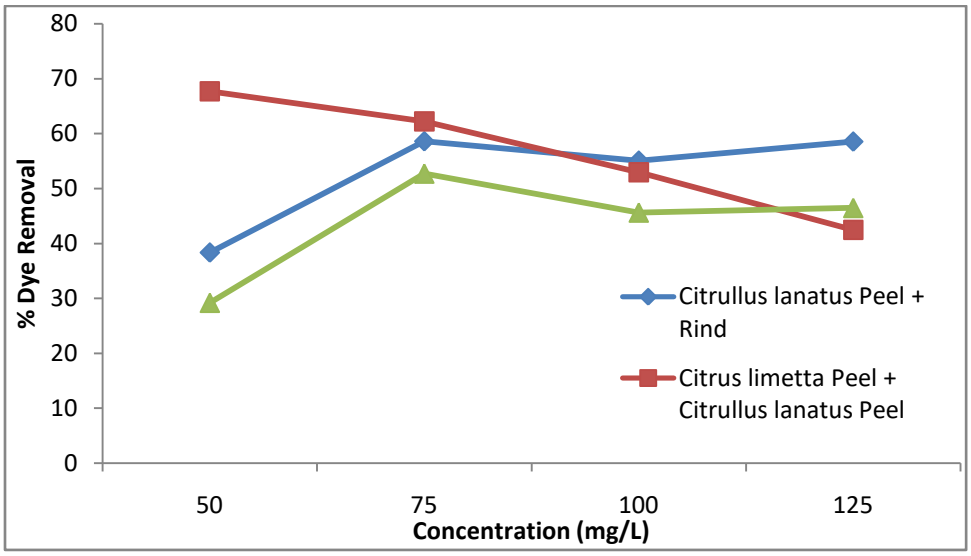

Figure 5 Percentage Dye Removal of Brilliant Green Dye with Mixture of Adsorbents at Adsorbent Dose of 1 gm and size 0.246 mm

Figure 6 shows the overall changes in percentage of dye removal from initial to final concentration of dyes with mixture of adsorbents. The overall percentage removal of CV and BG dyes with adsorbent mixture of *Citrullus lanatus* Peel + *Citrus limetta* Peel is found to be similar and decrease to 38.09% and 37.63% respectively. With *Citrullus lanatus* Peel + Rind, the overall dye removal efficiency decreases to 9.54% for CV dye whereas it increases to 53.11% with BG dye. There has been 277.46% and 59.86% overall increase in CV and BG dye removal efficiencies respectively with *Citrus limetta* Peel + *Citrullus lanatus* Rind. This study has shown that the mixture of *Citrullus lanatus* Peel + *Citrus limetta* Peel is effective in decolorizing both CV and BG dyes at 50 mg/L while the adsorbent mixture *Citrullus lanatus* Peel + Rind is efficient in decolorizing CV dye at lower concentration of 50 mg/L and BG dye at higher concentration of 125 mg/L. But at higher dye concentration of 125 mg/L, the adsorbent mixture *Citrus limetta* Peel + *Citrullus lanatus* Rind is very efficient in decolorizing CV and BG dyes.

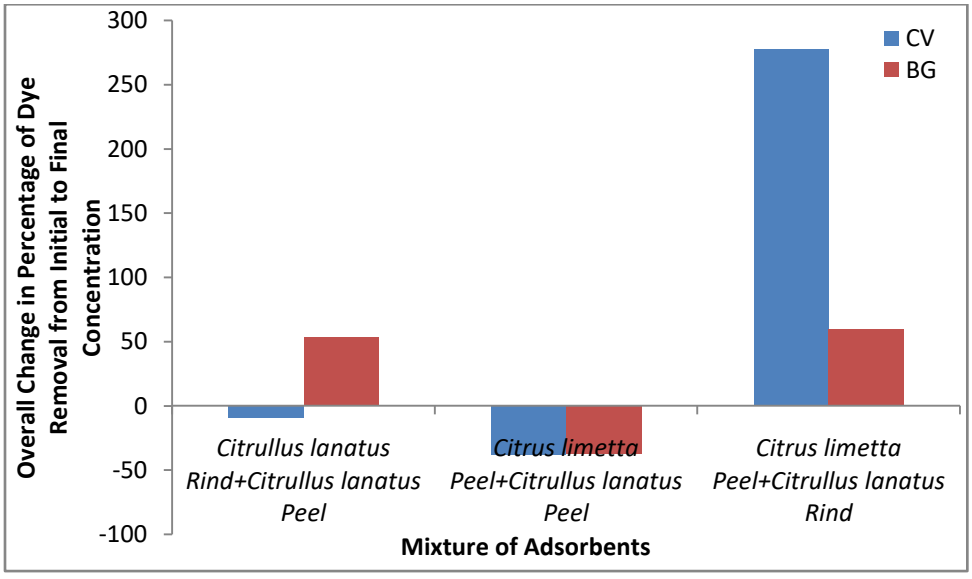

Figure 6 Overall Changes in Percentage of Dye Removal from Initial to Final Concentration of Dyes with Mixture of Adsorbents

4. Conclusion

Single adsorbents *Citrullus lanatus* Rind is effective in decolourizing Crystal Violet dye at concentration of 50 mg/L. *Citrus limetta* Peel is very effective in decolourizing Crystal Violet dye and also can decolourize Brilliant Green dye significantly at concentration of 50 mg/L. *Citrullus lanatus* Peel is effective in decolourizing Crystal Violet and Brilliant Green dyes at 50 mg/L and also 125 mg/L. Mixture of adsorbents *Citrullus lanatus* Peel + *Citrus limetta* Peel is effective in decolorizing both Crystal Violet and Brilliant Green dyes at 50 mg/L while the adsorbent mixture *Citrullus lanatus* Peel + Rind is efficient in decolorizing Crystal Violet dye at lower concentration of 50 mg/L and Brilliant Green dye at higher concentration of 125 mg/L. But at higher dye concentration of 125 mg/L, the adsorbent mixture *Citrus limetta* Peel + *Citrullus lanatus* Rind is very efficient in decolorizing Crystal Violet and Brilliant Green dyes.

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References

Abbas A., Murtaza S. and Munir M., (2011), "Removal of Congo Red from Aqueous Solutions with *Raphanussativus*Peels and Activated Carbon: A Comparative Study", American-Eurasian Journal of Agricultural and Environmental Science, Vol. 10, No. 5, pp 802-809.

Abdul Karim S. K., Rabuyah NI., Asli M A. and Ismail S H., (2015)., "Removal of Crystal Violet Dye Using Sugarcane Fibre", Transactions on Science and Technology, Vol. 2, No. 2, pp. 11 – 15.

Karthik J. P. M., Swathik H, Baskar U. S., Sivamani S., (2012), "Removal of Direct Red Dye Using Neem Leaf Litter", Helix, Vol. 1, No. 2, pp 129 – 133.

Sharma A. and Bhattacharya K. G., (2005), "Utilization of a Biosorbent based on *Azadirachtaindica*(Neem) Leaves for Removal of Water- Soluble Dyes", Indian Journal of Chemical Technology, Vol. 12, pp. 285 – 295.

Sudevi Basu, Juhi, Kavya H, Rajlaxmi Dash and Sumi, (2017).," Comparison of Decolourizing Efficiency of Waste Pisum Sativum Pod Adsorbent on Single and Mixture of Synthetic Dyes", International Journal for Scientific Research & Development, Vol. 5, Issue 06, pp 845 – 851.

Vinoth M., Lim H. Y., Xavier R., Marimuthu K., Sreeramanan S., Rosemal M. H. M. H. and Kathiresan S., (2010), "Removal of Methyl Orange from Solutions Using Yam Leaf Fibres", International Journal of Chem Tech Research, Vol. 2, No. 4, pp 1892 – 1900.