Decolourization of Synthetic Dyes using Eco-Friendly Fruit and Vegetable Peel Adsorbents

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Abstract: ***The synthetic dyes are bright in colour and cause water pollution when discharged into water bodies and adsorption is found to be a simple and cost effective method for removal of colour from synthetic dyes. This research is carried out to investigate the decolourization efficiencies of eco-friendly, cost effective adsorbents from fruit and vegetable peels (Watermelon Peel (WMP), Watermelon Rind (WMR), Mosambi Outer Peel (MOP), Mosambi Inner Peel (MIP), Papaya Peel (PAPP) and Potato Peel (POTP) on four synthetic dyes (Crystal Violet, Methylene Blue, Malachite Green and Methyl Orange). This research revealed that all fruit and vegetable peel adsorbents were found to be effective in removal of synthetic dyes at 100 mg/L (84.93% and 87.25% crystal violet and methylene blue dyes with watermelon peel; 68.49%, 51.96% and 34.78% crystal violet, methylene blue and malachite green dyes with mosambi outer peel; 35.62%, 53.92% and 63.04% crystal violet, methylene blue and malachite green dyes with potato peel; 57.53% and 52.17% crystal violet and malachite green dyes with papaya peel; 39.22% and 39.13% methylene blue and malachite green dyes with mosambi inner peel and 58.82% and 56.52% methylene blue and malachite green dyes with watermelon rind). Further it was found that these adsorbents could also decolourize dyes at 500 mg/L (52.9% methylene blue dye with papaya peel; 38.68% and 19.81% crystal violet dye with mosambi inner peel and watermelon rind respectively; 30.51% and 25.42% methyl orange dye with watermelon rind and papaya peel respectively). Also it was seen that four adsorbents had very low percentage removal for methyl orange dye (2.27%, 3.41%, 5.68% and 10.22% with watermelon peel, mosambi inner peel, potato peel and mosambi outer peel respectively) at 100 mg/L and potato peel adsorbent had very low percentage removal for methyl orange dye (2.54%) even at 500 mg/L.***

Keywords: Synthetic Dyes, Water Pollution, Decolourization, Adsorption, Adsorbents

1. Introduction

Synthetic dyes are a common pollutant in effluents from textiles, rubber, paper and pulp industries. These dyes are difficult to degrade due to their complex aromatic structures, persist in the environment, pollute the water bodies and affect aquatic life and enter into food webs and have carcinogenic and mutagenic effects (Sharma *et al*., 2005; Tahir *et al*., 2008; 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). Adsorption has proved to be an effective method for removal of dye from wastewater due to simplicity, cost effectiveness, ease of operation, insensitivity towards toxic substances and high efficiency, as well as the availability of a wide range of adsorbents. (Sharma *et al*., 2005; Karthik *et al*., 2012). Activated Carbon is the most commonly used adsorbent but its large scale use is limited owing to high cost, at least in developing countries (Voudrias *et al*., 2002; Sharma *et al*., 2005; Santhi *et al*., 2010; Fathi *et al*., 2011; Karthik *et al*., 2012). Thus the need of the hour is to test the use of low cost naturally available agro based waste as adsorbents for successfully treating colour from dyes. Several researchers have used different low cost adsorbents for removing dyes like, papaya seeds (Nasuha *et al*., 2011), Annona squmosa seed from a hedge plant (Santhi *et al*., 2010), Banana trunk fibres (Rosemal *et al*., 2010),Yam leaf fibres (Vinoth *et al*., 2010), Cassave peel waste (Adowei *et al*., 2012),Hazelnut seeds (Fathi *et al*., 2011). This research is carried out to study the efficiencies of colour removal of four synthetic dyes (Crystal Violet, Methylene Blue, Malachite Green and Methyl Orange) with fruit and vegetable peel adsorbents like Watermelon Peel (WMP), Watermelon Rind (WMR), Mosambi Outer Peel (MOP), Mosambi Inner Peel (MIP), Papaya Peel (PAPP) and Potato Peel (POTP).

2. Materials and Methods

2.1 Preparation of Adsorbent

Fruit and vegetable peels were collected from Sir MVIT college canteen. These were then washed with distilled water and thin layers of peels were obtained using a peeler. These peels were separately allowed to dry under the sun for an entire day till these became crisp and easy to be crushed. All the peels were then separately powdered in mixer. To ensure that the peels were completely decolourised, these were washed with distilled water and dried and the process was repeated two to three times. These were then passed through a 0.6 mm sieve to attain uniform particle size. The peel powder adsorbents were separately kept in the containers and properly labelled.

2.2 Preparation of Adsorbate

1g of each dye powder was taken and diluted with 1litre of distilled water separately and stored in different volumetric flasks.

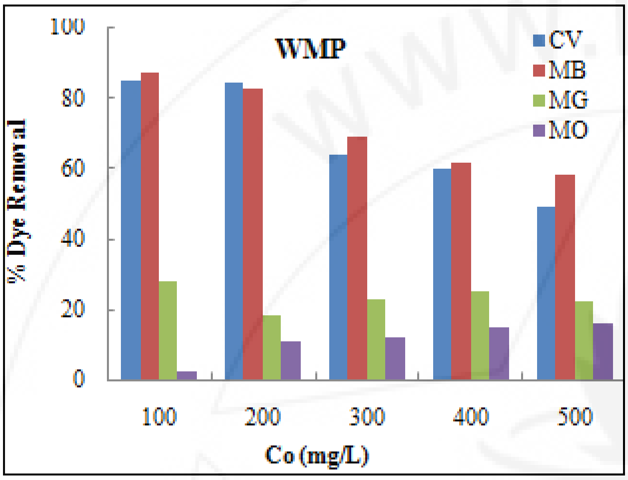
2.3 Batch Studies

Aliquots of different concentrations of the dyes were prepared to obtain solutions with concentrations (100-500mg/L). 0.5g of adsorbent was weighed and added to each of the conical flasks. This was repeated for each dye and adsorbent. The solutions were agitated at a constant speed and temperature using Secor India Griffin Flask Shaker for 75 minutes. The adsorbate was filtered out using ordinary filter paper from each of the conical flasks in order to get a clear solution. OD was taken at the respective nanometers for each dye used (Crystal Violet – 590 nm, Methylene Blue – 650 nm, Malachite Green – 650 nm and Methyl Orange – 490 nm). The percentage removal of adsorbate adsorbed on the adsorbent is given as

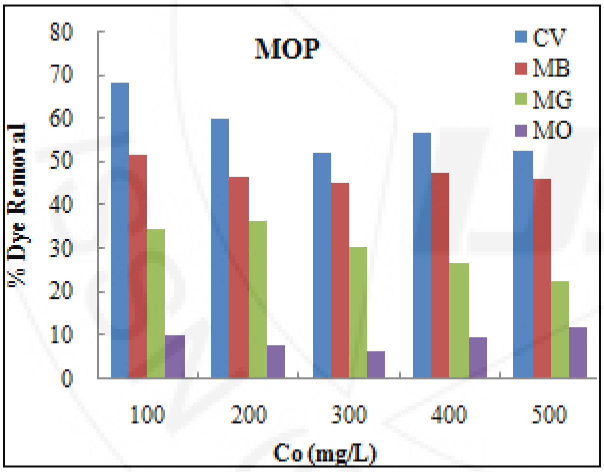
$$\%Dye\,Removal = \frac{(C_o - C_f)}{C_o} \times 100 \text{--------(1)}$$

Where C_o = Initial concentration of dye (mg/L)
C_f = Final concentration of dye (mg/L)

3. Results and Discussions



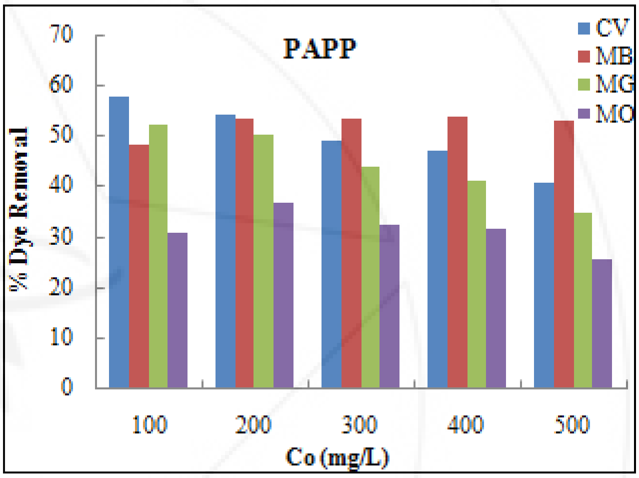
(a)



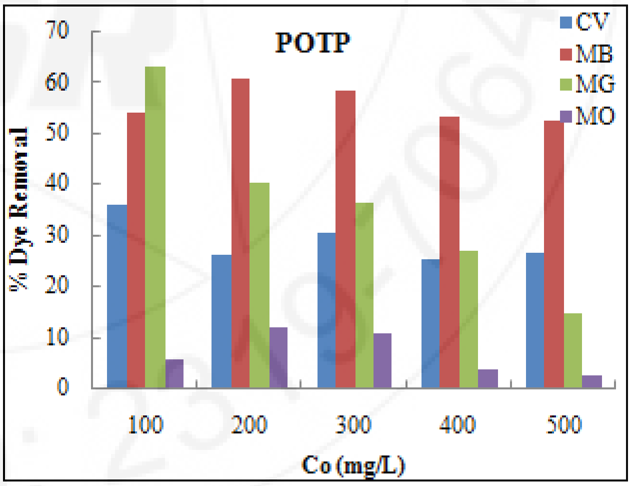
(b)

Figure 1: Effectiveness of 0.5 g Adsorbents (a) Watermelon Peel and (b) Mosambi Outer Peel in Removal of Dyes at Different Concentrations

From figure 1(a), it was observed that for a fixed watermelon peel adsorbent dose of 0.5 g, the percentage dye removal decreased with increase in initial concentration of crystal violet and methylene blue dye (100 – 500 mg/L). There was 84.93% and 87.25% dye removal at 100 mg/L and it decreased to 49.06% and 58.06% for crystal violet and methylene blue dyes respectively. The rapid initial stage of dye removal with this adsorbent is attributed to the abundant availability of active sites on adsorbent and with gradual occupancy of these sites, the sorption becomes less efficient. The results are in accordance with previous studies (Bhattacharya *et al*., 2003; Rosemal *et al*., 2010; Karthik *et al*., 2012). Similarly, for malachite green dye, the initial dye removal was 28.26% at 100 mg/L and decreased to 22.66% at 500 mg/L. However for methyl orange dye, the initial stage of dye removal was slow i.e., 2.27% with 100 mg/L and increased to 16.10% at 500 mg/L. This is because of increased interactions between dye molecules and surface of adsorbents and might be due to the fact that 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 (Vinoth *et al*., 2010). Figure 1(b) showed a similar trend with mosambi outer peel adsorbent at 0.5 g for crystal violet, methylene blue and malachite green dye. The initial stage of dye removal with this adsorbent was high at 68.49%, 51.96% and 34.78% at 100 mg/L and decreased to 52.83%, 46.45% and 22.67% at 500 mg/L for crystal violet, methylene blue and malachite green dye respectively. The dye removal of methyl orange remained constant at 10.22% to 11.86% at 100 mg/L and 500 mg/L respectively.



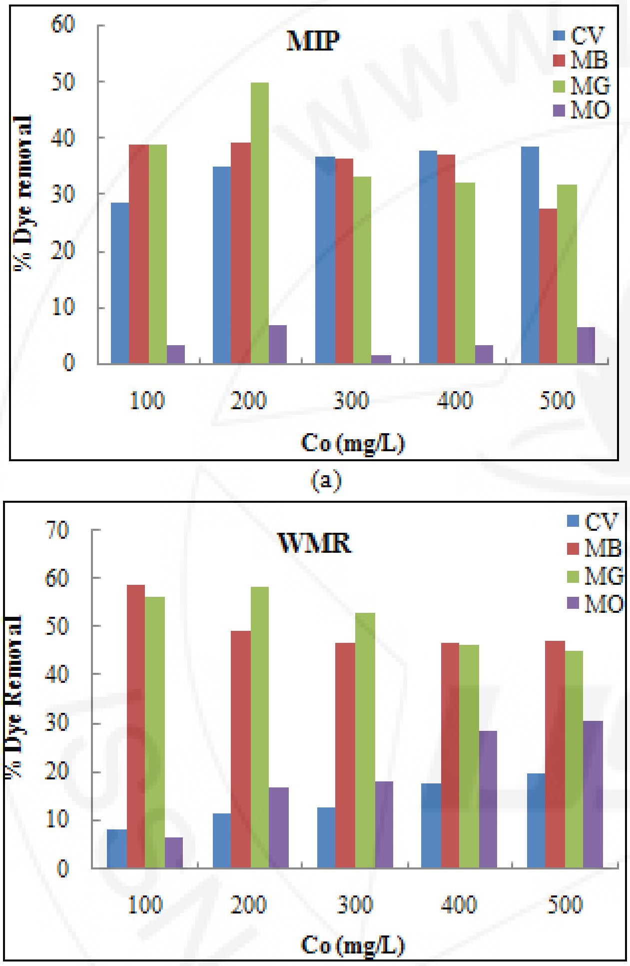
(a)



(b)

Figure 2: Effectiveness of 0.5 g Adsorbents (a) Papaya Peel and (b) Potato Peel in Removal of Dyes at Different Concentrations

In figure 2(a), 0.5 g of papaya peel adsorbent was found to adsorb 57.53%, 48.04%, 52.17% and 30.68% crystal violet, methylene blue, malachite green and methyl orange dyes respectively at 100 mg/L. The percentage dye removal decreased to 40.57%, 34.67% and 25.42% for crystal violet, malachite green and methyl orange dyes respectively but increased marginally to 52.9% for methylene blue dye at 500 mg/L. Figure 2(b) showed a high percentage dye removal of 35.62%, and 63.04% for crystal violet and malachite green dyes respectively at 100 mg/L with potato peel adsorbent. The dye removal percentage declined to 26.42% and 14.67% for crystal violet and malachite green dyes respectively at 500 mg/L. Similar trend was observed for methyl orange dye and percentage removal was low 5.68% at 100 mg/L and it decreased further to 2.54% at 500 mg/L. However for methylene blue dye, the percentage dye removal was 53.92% at 100 mg/L, increased and then remained almost constant at 52.26% at 500 mg/L.



(b)

Figure 3: Effectiveness of 0.5 g of Adsorbents (a) Mosambi Inner Peel and (b) Watermelon Rind in Removal of Dyes at Different Concentrations

Figure 3(a) showed a reverse trend for crystal violet dye with mosambi inner peel adsorbent than other adsorbents. Here the percentage dye removal was 28.77% at 100 mg/L and increased to 38.68% at 500 mg/L. This indicates that mosambi inner peel is capable of removing crystal violet dye at higher concentration. Similar trend was observed with methyl orange dye but removal efficiency was low (3.41% at 100 mg/L and 6.78% at 500 mg/L). The other two dyes methylene blue and malachite green had high percentage removal (39.21% and 39.13%) respectively at 100 mg/L and decreased to 27.74% and 32% respectively at 500 mg/L. From figure 3(b), it was observed that watermelon rind adsorbent could remove 8.22% and 6.82% of crystal violet and methyl orange dyes respectively at 100 mg/L and it increased to 19.81% and 30.51% for the two dyes respectively at 500 mg/L. However a decreasing percentage removal of dye was observed for methylene blue and malachite green dyes (58.82% and 56.52%) respectively at 100 mg/L and (47.10% and 45.33%) respectively at 500 mg/L.

4. Conclusions

From this research it was seen that watermelon peel, mosambi outer peel, potato peel adsorbents were effective in removal of crystal violet, methylene blue and malachite green dyes at 100 mg/L but dye removal efficiency reduced at 500 mg/L. Similarly mosambi inner peel and watermelon rind adsorbents were efficient in removal of methylene blue and malachite green dyes at 100 mg/L and the efficiency decreased at 500 mg/L. This research also revealed that watermelon peel, mosambi inner peel and watermelon rind adsorbents were capable of removing less percentage of methyl orange dye at 100 mg/L and the percentage dye removal increased at 500 mg/L. Further it was seen that papaya peel adsorbent could remove crystal violet, malachite green and methyl orange dyes at 100 mg/L and removal percentage decreased at 500 mg/L. Hence all fruit and vegetable peel adsorbents in this research were found to be effective in removal of synthetic dyes crystal violet, methylene blue, malachite green and methyl orange except potato peel adsorbent which had very low percentage removal for methyl orange dye even at 100 mg/L.

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