Synthesis of Modified Coffee Ground Adsorbents to Remove Malachite Green Dye

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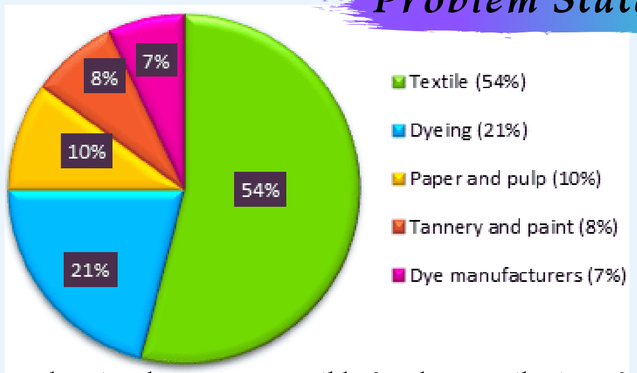
Chemical Engineering | Environmental Technology | Transdisciplinary Element | Statistical Analysis

Coffee waste was modified as a low-cost adsorbent for the adsorption of malachite green (MG) dye molecules. The coffee ground (CG) waste was modified using chemical activation by utilizing potassium hydroxide (KOH) and hydrochloric acid (HCl). Optimization of operating parameters for preparation of MCG adsorbent to remove MG dye molecules was carried out using central composite design. Based on Response Surface Methodology, the optimum process conditions obtained was at pH 7.3, contact time of 6.9 hours and adsorbent dosage of 0.2 g while the maximum MG dye removal percentage was 85.02 % and adsorption capacity of 1.65 mg/g. The MCG was characterized in terms of surface area, surface morphology, surface chemistry and elemental analysis by using Brunauer–Emmett–Teller (BET), Fourier transform infrared spectroscopic (FTIR), scanning electron microscopic (SEM) and CHNS analyzer. MCG showed a better characterization result compared to untreated CG. The effect of initial dye concentration, contact time, solution pH and adsorbent dosage for adsorption of MG dye was investigated for equilibrium and kinetic study. Freundlich isotherm model was found perfectly fitted model to explain the adsorption behaviour of MG adsorption and pseudo second order model plot was best fitted by using linear regression analysis.

Problem Statement



Industries that are responsible for the contribution of dye effluents in environment.

Due to the high demand for dyes in the industries, dye-containing effluents are increasing tremendously in the environment. The wastewater produced from these dye-utilizing industries will result in the environmental pollution where dyes tend to break down into smaller products that can be toxic and hazardous for all living organisms.

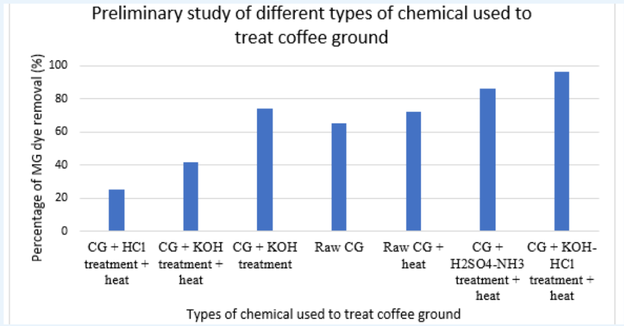
Proposed Solution

Adsorption Process
- Efficient process
- Low-cost
- Design simplicity
- Flexibility in design and process operation
- No formation of hazardous intermediates products from the process

Coffee Waste
- Cost-effective
- Renewable source
- Environmental friendly
- Readily available in huge amount

Modified Coffee Waste
- Enhance the adsorption efficiency
- Improve its performances characteristics

Preliminary Study



- Coffee ground treated with KOH and HCl with the heat treatment showed the highest MG dye removal percentage of 96.14 % and 23.51 mg/g of adsorption capacity of MCG.

Flow chart of Coffee Ground Synthesis

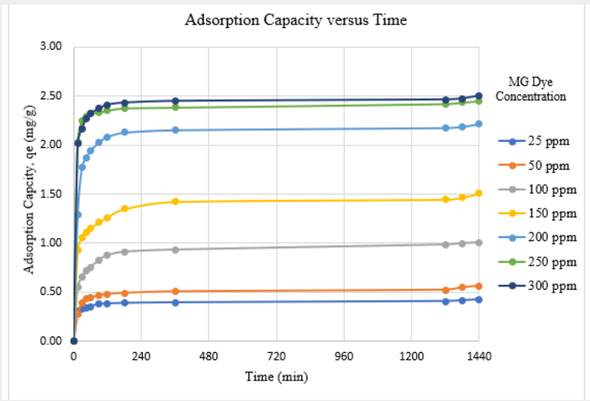
Collect coffee waste
↓
Wash with boiled and distilled water
↓
Dried in oven
↓
Sieved
↓
Coffee ground soaked in KOH
↓
Dried in oven
↓
Carbonized in mircowave using CO_2
↓
Coffee ground soaked in HCl
↓
Dried in oven
↓
Rinsed with distilled water
↓
Dried in oven
↓
Sieved
↓
Modified coffee ground

Optimization of Parameter

Optimum Condition	pH	7.31
	Contact time (hrs)	6.95 hrs
	Adsorbent Dosage (g)	0.2 g
Optimum Response	Percentage of MG dye removal (%)	83.51 %
	Adsorption capacity of MCG (mg/g)	1.40 mg/g

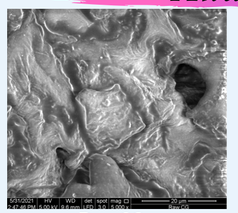
- Optimization is done using Response Surface Methodology.

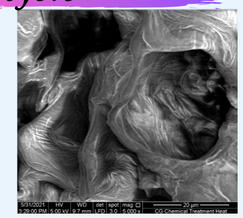
Batch Adsorption Study

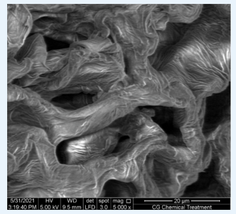


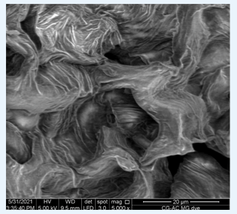
- The dye removal is fast in the beginning, but gradually slows down as it approaches equilibrium.
- The rate of MG dye removal was rapid before reaching equilibrium state at around 120 minutes.
- Due to the availability of large number of vacant sites during initial stage of adsorption.

Surface Morphology Analysis


Raw CG


CG + chemical treatment


CG + chemical treatment+ heat


Malachite green adsorbed CG

- SEM analysis used to analyse the morphological texture of four different adsorbent surface and images for before and after adsorption process can be seen.

Surface Area Analysis

Adsorbent	BET Surface Area (m^2/g)
Raw CG	3.4137
CG + chemical treatment	3.8378
CG + chemical treatment + heat	3.7023
CG – AC + MG dye	1.1436

- Carbon, Hydrogen, Nitrogen and Sulphur (CHNS) analyzer was used to analyze the chemical compositions of the samples.
- Raw CG showed a higher composition of C (51.36 %), H (6.97 %), N (2.75 %) and S (0.46 %) compared to other samples.

Acknowledgment

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