# COMPARATIVE ANALYSIS OF LIQUID-SOLID ADSORPTION ON DIFFERENT GRADES OF CHARCOAL

Presented by Group 14:
Kumar Shubham,
Nirjala Kushwaha,
Pawar Vivek,
Prathvi Rathore

# INTRODUCTION

Adsorption is widely used in chemical, environmental, and biochemical industries for removing contaminants from liquids and gases. Activated charcoal is a common adsorbent due to its high surface area and porosity.

**Problem Statement:** Different grades of charcoal have varying purities and surface properties, which influence their adsorption performance. Selecting the most efficient charcoal grade for specific applications requires comparative analysis.

**Objective:** To analyze and compare the adsorption behavior of laboratory-grade and industrial-grade charcoal in a packed bed column using $KMnO_4$ as the adsorbate.

# INNOVATIVE ASPECTS

Material Innovation: Use of different grade of charcoals

Comparative Adsorption Study

Performance Benchmarking of Low-Cost Alternatives

# APPARATUS AND SETUP


Adsorber column


Liquid solid adsorption in Packed Bed Apparatus

# THEORY

Adsorption is defined as the selective concentration of one or more components of a mixture on a solid surface. The solid that adsorbs a component is called the adsorbent, and the component adsorbed is called the adsorbate. The adsorption process is a result of the interaction between the adsorbate molecule and the surface (or pore wall) of the adsorbent.

At this point, it should be noted that when a component is selectively transferred into a bulk medium rather than the surface, it is known as absorption. The adsorption phenomenon provides an excellent method of separating a variety of fluid mixtures, especially at low concentrations.

# METHODOLOGY

Preparation:

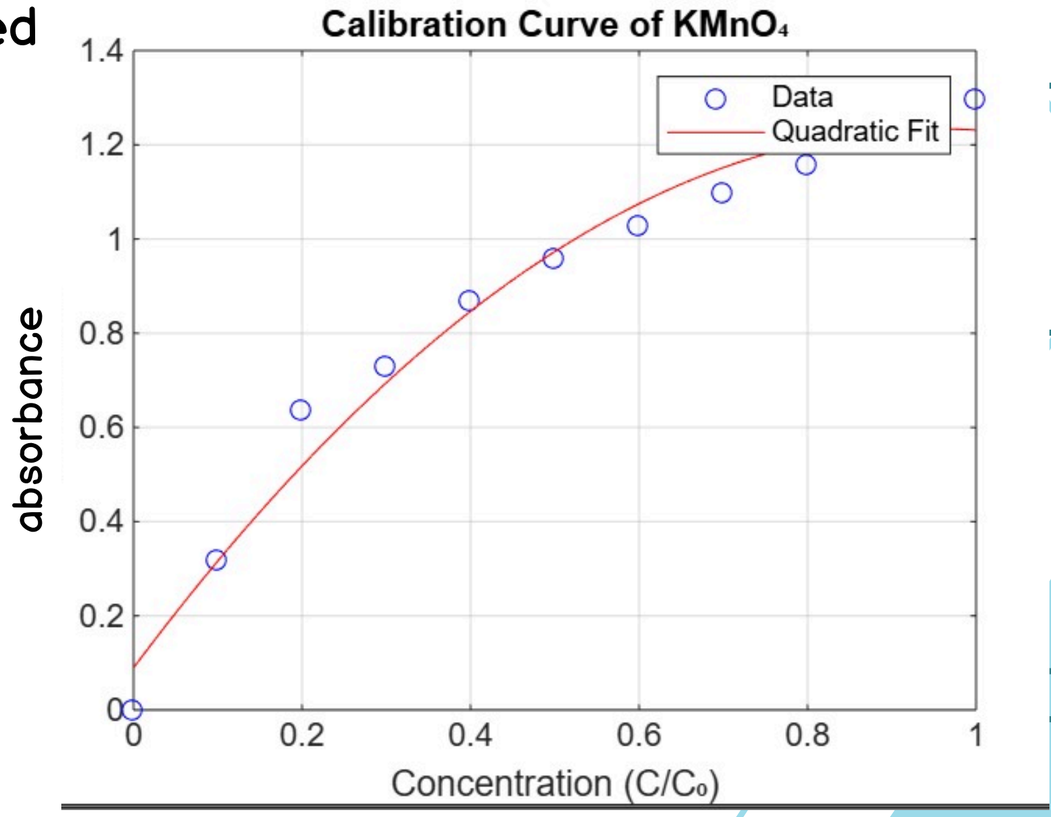
- Prepare $KMnO_4$ stock solution.
- Calibrate colorimeter with standard $KMnO_4$ concentrations.
- Pack the column with
  - 100% commercial
  - 50-50 mixed charcoal (Commercial + Laboratory)

Procedure:

- Initiate pump to set flow to 30 LPM.
- Start stopwatch when solution enters column.
- Collect effluent samples at 2-min intervals.
- Measure absorbance of each sample.
- Convert to concentration using calibration curve.

# Caliberation data :-

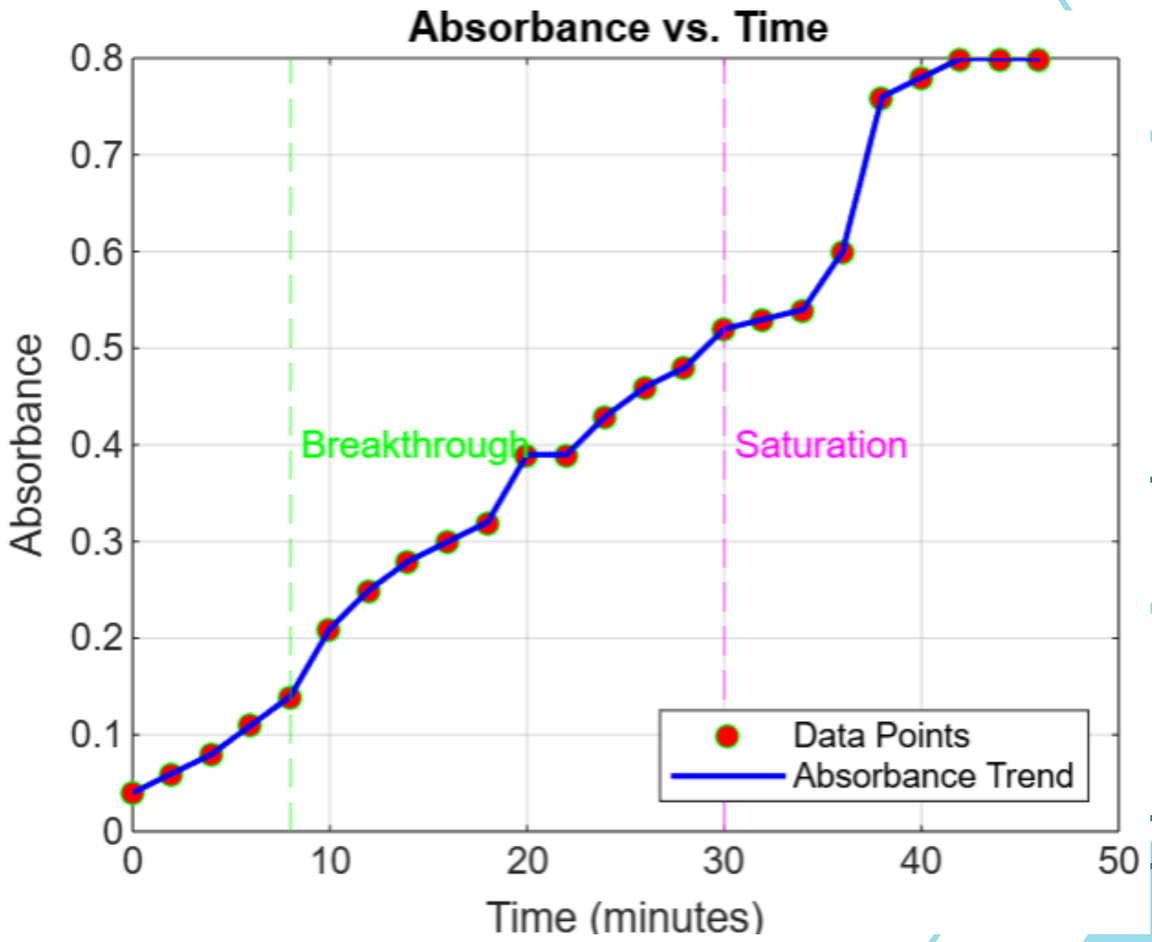
- KMnO4 in feed is used to for calibration of data to find the relation between **Adsorption vs Concentration**.
- Using the data points at various concentrations of KMnO4 we curve fitted the quadratic equation which can be further used relational equation.



# OBSERVATION

- Commercial + Lab Grade Charcoal


Outlet



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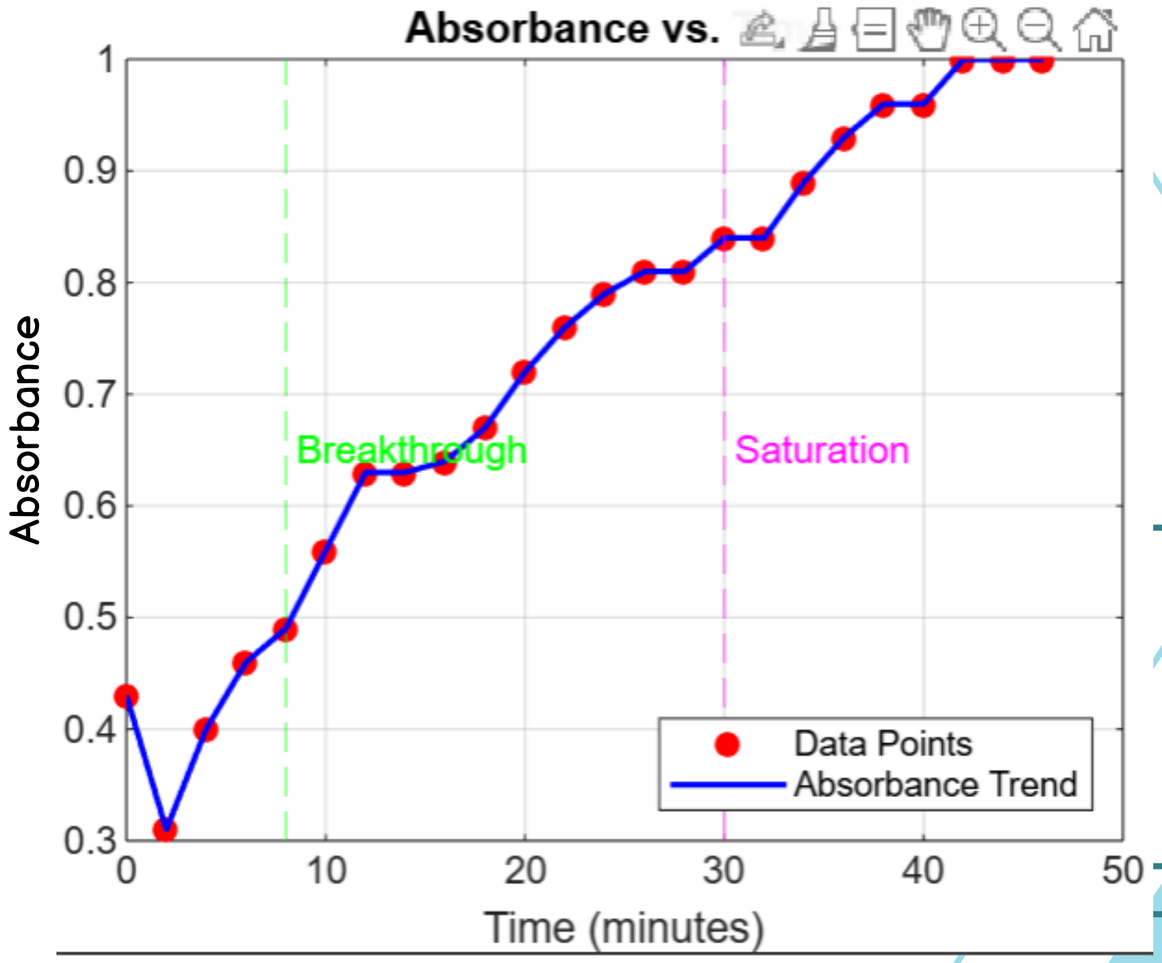

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## Commercial Grade Charcoal


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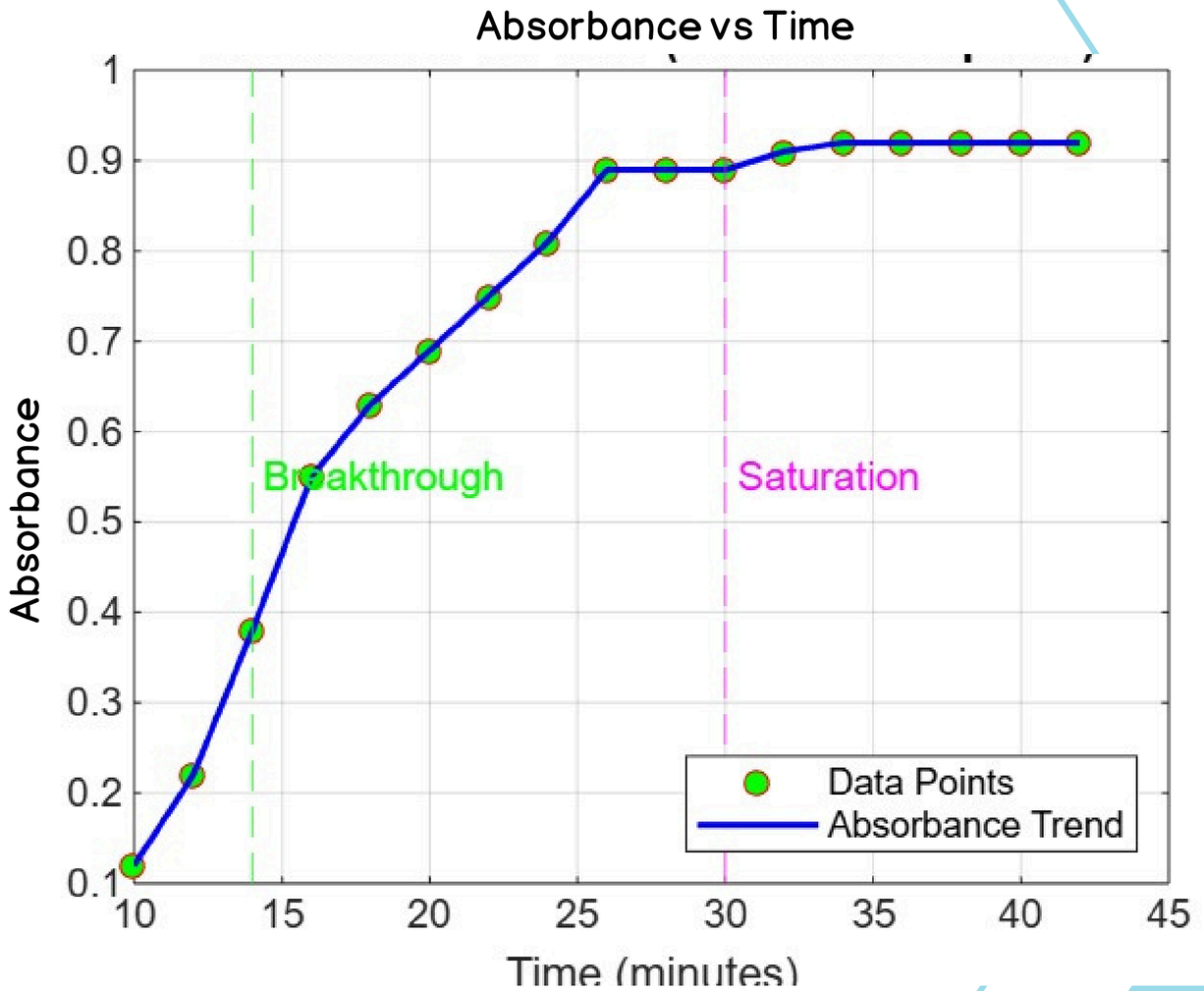

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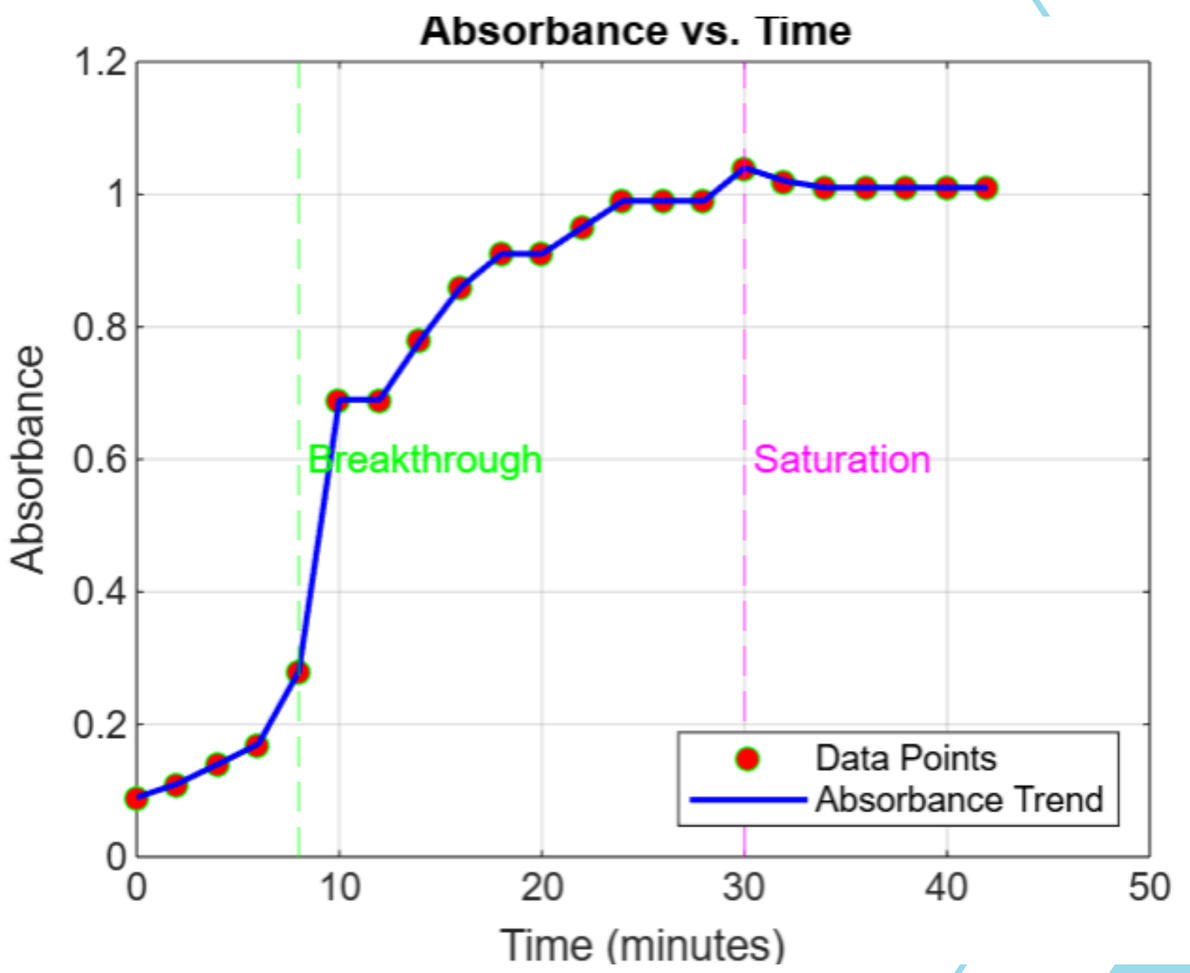
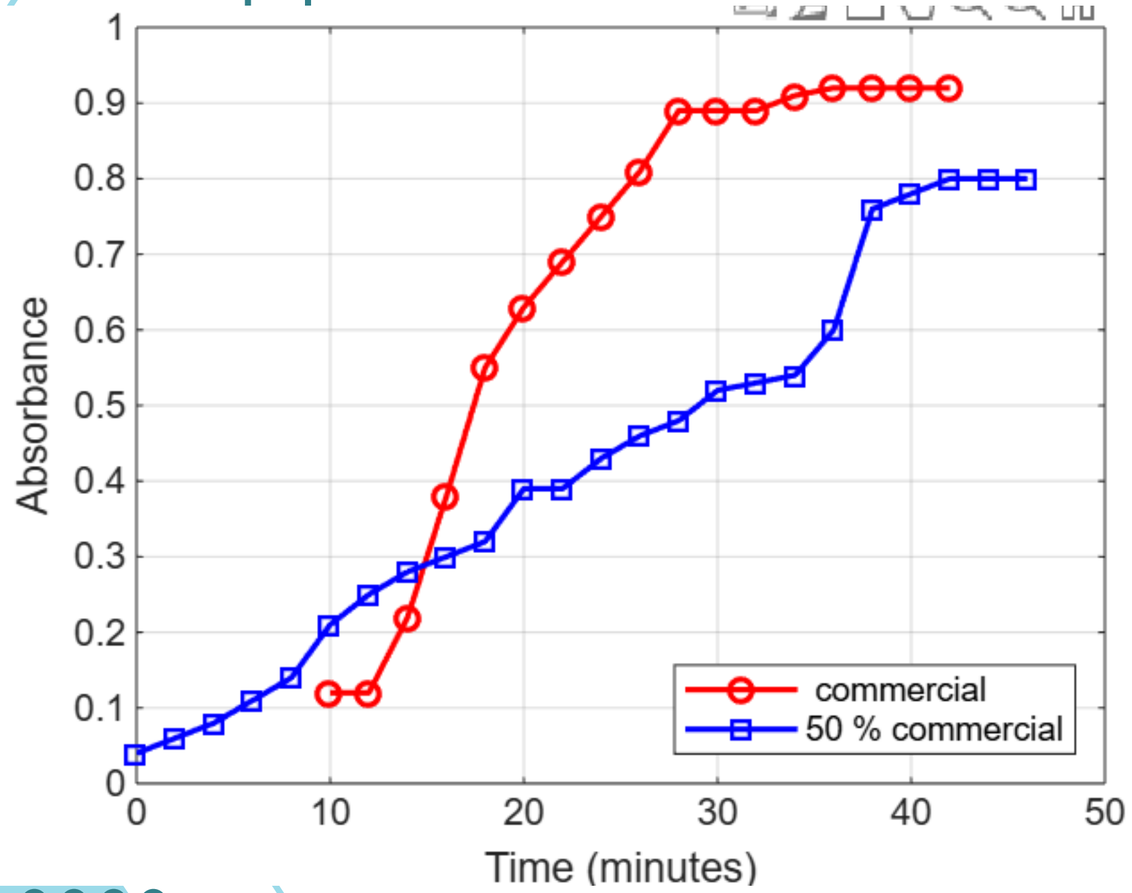
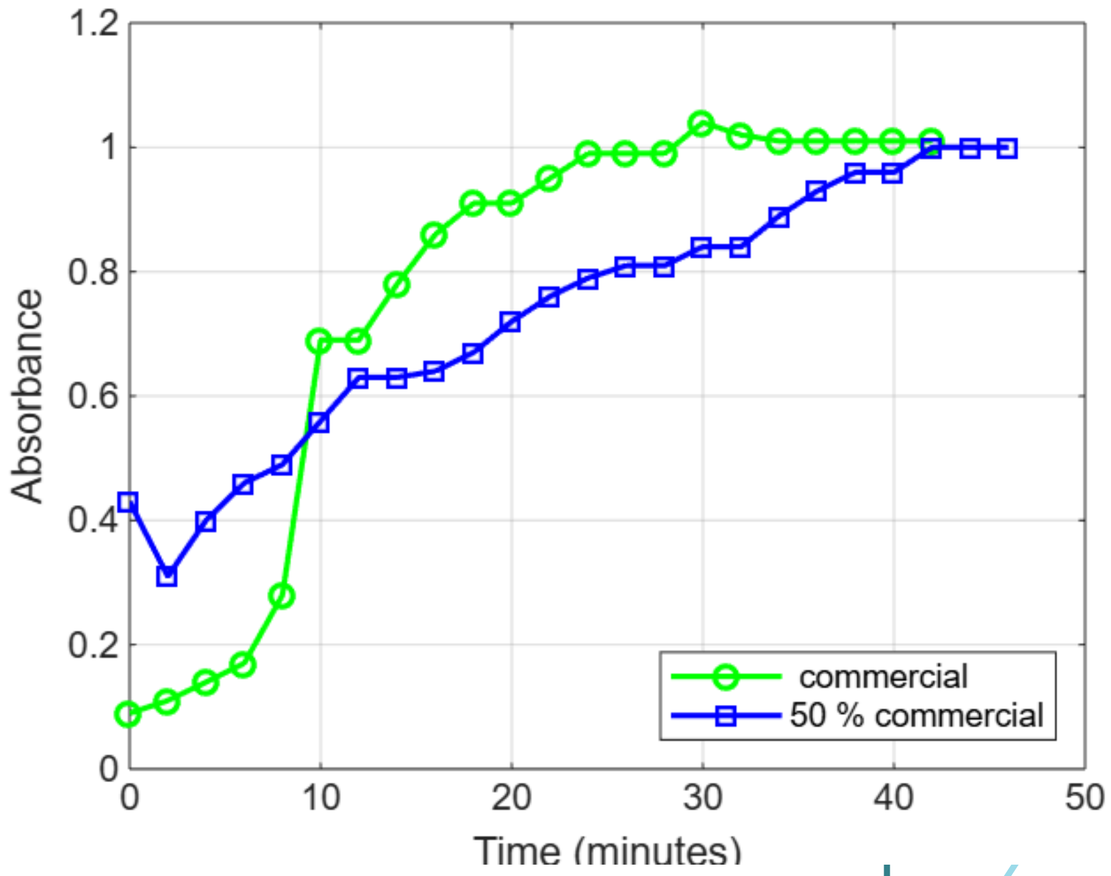


# Comparative analysis




Rear flow




Column flow

# Comparative analysis

- When comparing the absorbance of $KMnO_4$ in both outflows, a common trend is observed.
- Initially, the commercial-grade charcoal exhibits lower absorbance than the mixed-grade charcoal. However, after a certain point, the commercial-grade charcoal surpasses the mixed-grade in absorbance performance, eventually reaching a saturation point where the values stabilize ( this means that the concentration is higher therefore lesser adsorption occurred).
- In the column flow sample collected, the value of absorbance reaches the same value eventually while for the rear flow it doesn't.

# Theoretical Backing

- Although both charcoal grades possess similar physical characteristics—such as particle size, porosity, and surface area—their performance in adsorbing $KMnO_4$ differs due to variations in surface chemistry and purity. Laboratory-grade charcoal, being of higher purity, contains fewer impurities and functional groups that may hinder adsorption. This allows it to adsorb $KMnO_4$ more effectively from the solution.
- As a result, the concentration of $KMnO_4$ remaining in the solution is lower, which is reflected in the reduced absorbance values. In contrast, industrial-grade (or commercial-grade) charcoal, with relatively lower purity, exhibits less efficient adsorption, leading to higher absorbance readings.

# Surprising results

- Through our analysis, we were able to provide a solid explanation for the higher overall adsorption capacity of mixed-grade charcoal compared to other grades. However, the underlying cause for the initial rapid increase in adsorption values observed in the early stages of the process remains unexplained and warrants further investigation.
- Possible reasons :-

1. Surface Chemistry and Purity:

2. Pore Structure and Accessibility:

3. Kinetics vs. Capacity:

# THANK YOU