CHE 213
INNOVATION PROJECT

Group 17

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INNOVATION

Performed adsorption of a concentration of KMnO4 solution in two different types of packed bed (**chalk pieces** and **activated charcoal**) to compare the extent of adsorption in both beds.

THEORY

Adsorption is the process where a solute is selectively transferred from a fluid (liquid or gas) onto the surface of solid particles. Certain solid materials, called **adsorbents**, can attract and hold specific solutes more than others, making it possible to separate them from a mixture. This happens because molecules in the fluid phase are attracted to the surface of the solid by weak forces like **van der Waals forces**. These forces exist because the atoms at the surface of the solid are not fully surrounded by other atoms and thus have **unsatisfied forces**.

Materials that are highly porous have a **large surface area**, which makes them especially effective as **adsorbents**.

PRINCIPLE

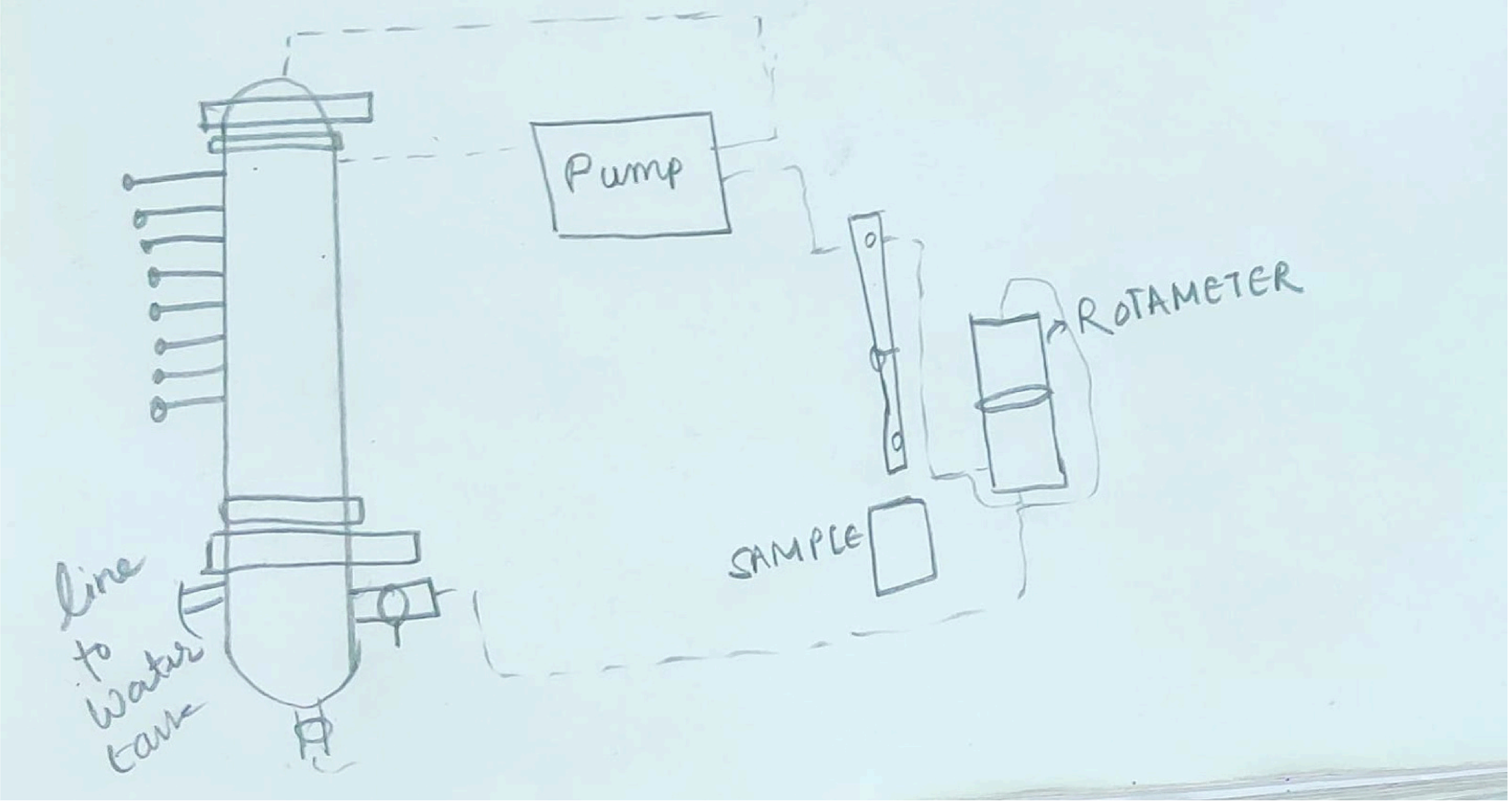
In **solid-liquid adsorption**, a solute (adsorbate) from a liquid solution accumulates on the surface of a solid material (adsorbent). Adsorption occurs due to **residual surface forces**, such as van der Waals interactions, present at the solid surface, which are capable of attracting and holding solute molecules from the fluid phase.

By passing $KMnO_4$ solution through packed beds of both adsorbents, the extent of adsorption can be compared by measuring the **absorptivity of the effluent,** which reflects the concentration of $KMnO_4$ remaining in the solution. A lower absorptivity indicates higher adsorption, as more $KMnO_4$ has been removed from the solution by the adsorbent.

APPARATUS REQUIRED

- Glass column.
- Packing material (chalk pieces and activated charcoal).
- Measuring cylinder/beaker.
- Funnel and filter paper; dropper.
- Colorimeter.

LINE DIAGRAM



Column (before)

Column (after)

Filtering the output

PROCEDURE

01

Prepare the calibration chart of KMnO4 for different amounts of dilution using the colorimeter.

02

Prepare a packed bed column with bed of chalk pieces and a feed of KMnO4 solution.

03

Open the valve of the column to be operated and start the pump.
Start the stopwatch.

04

Fix a flow rate using the rotameter.

PROCEDURE

05

Take the samples of the output from the column after fixed time intervals.

06

Measure the absorptivity by colorimeter and hence concentration of colour in the liquid.

07

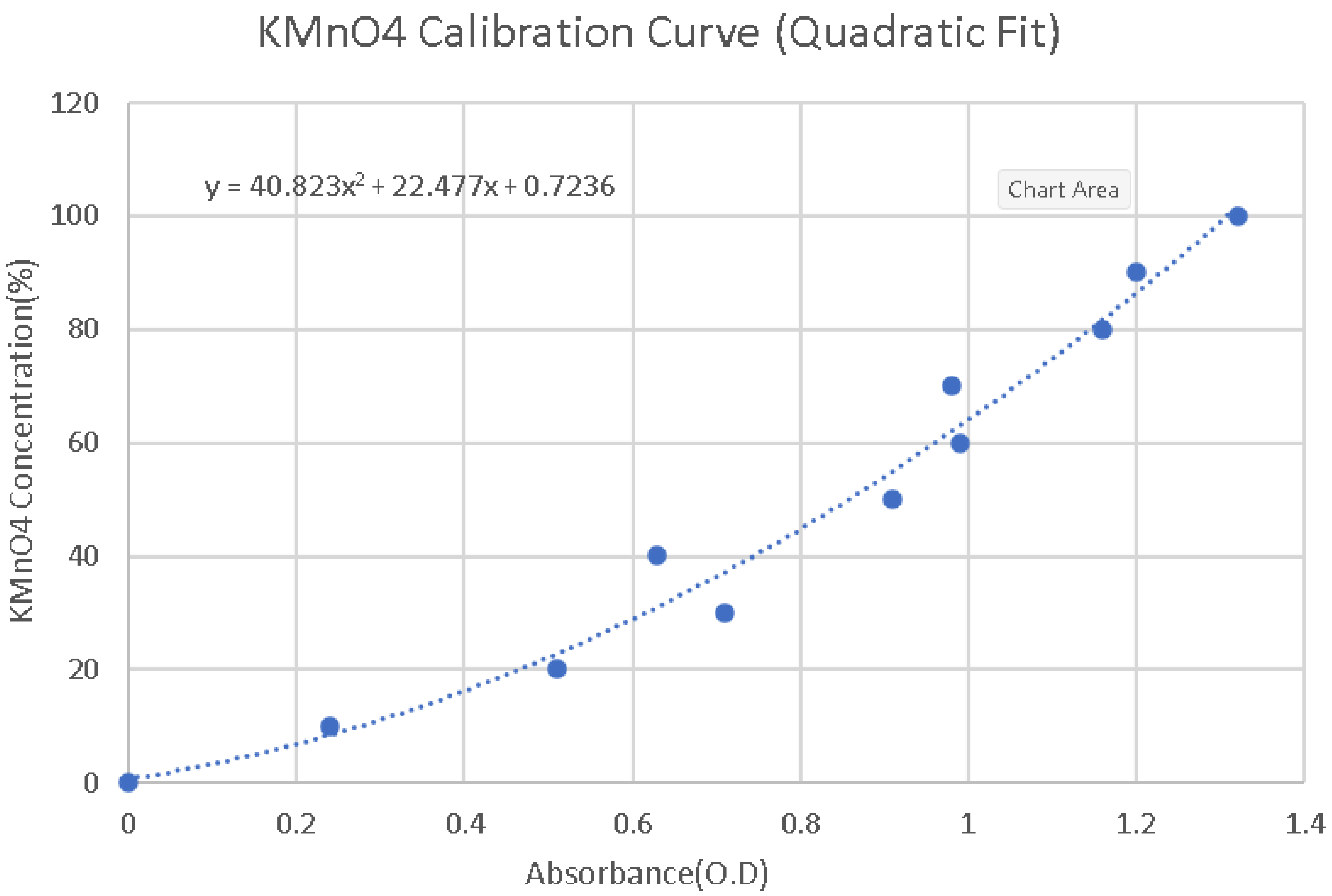
Run the fluid till the change in colour of output liquid becomes almost stable.

CALIBRATION OF KMNO4 VS DL WATER

For Chalk Bed

Total volume	$KMNO_4$ conc.(%)	DI Water conc. (in %)	$KMNO_4$ (mL)	DI water (mL)	Abs	% T
10 ml	0%	100%	0	10	0.0	
10 ml	10%	90%	1	9	0.24	
10 ml	20%	80%	2	8	0.51	
10 ml	30%	70%	3	7	0.71	
10 ml	40%	60%	4	6	0.63	
10 ml	50%	50%	5	5	0.91	
10 ml	60%	40%	6	4	0.99	
10 ml	70%	30%	7	3	0.98	
10 ml	80%	20%	8	2	1.16	
10 ml	90%	10%	9	1	1.20	
10 ml	100%	0%	10	0	1.32	

CALIBRATION CURVE



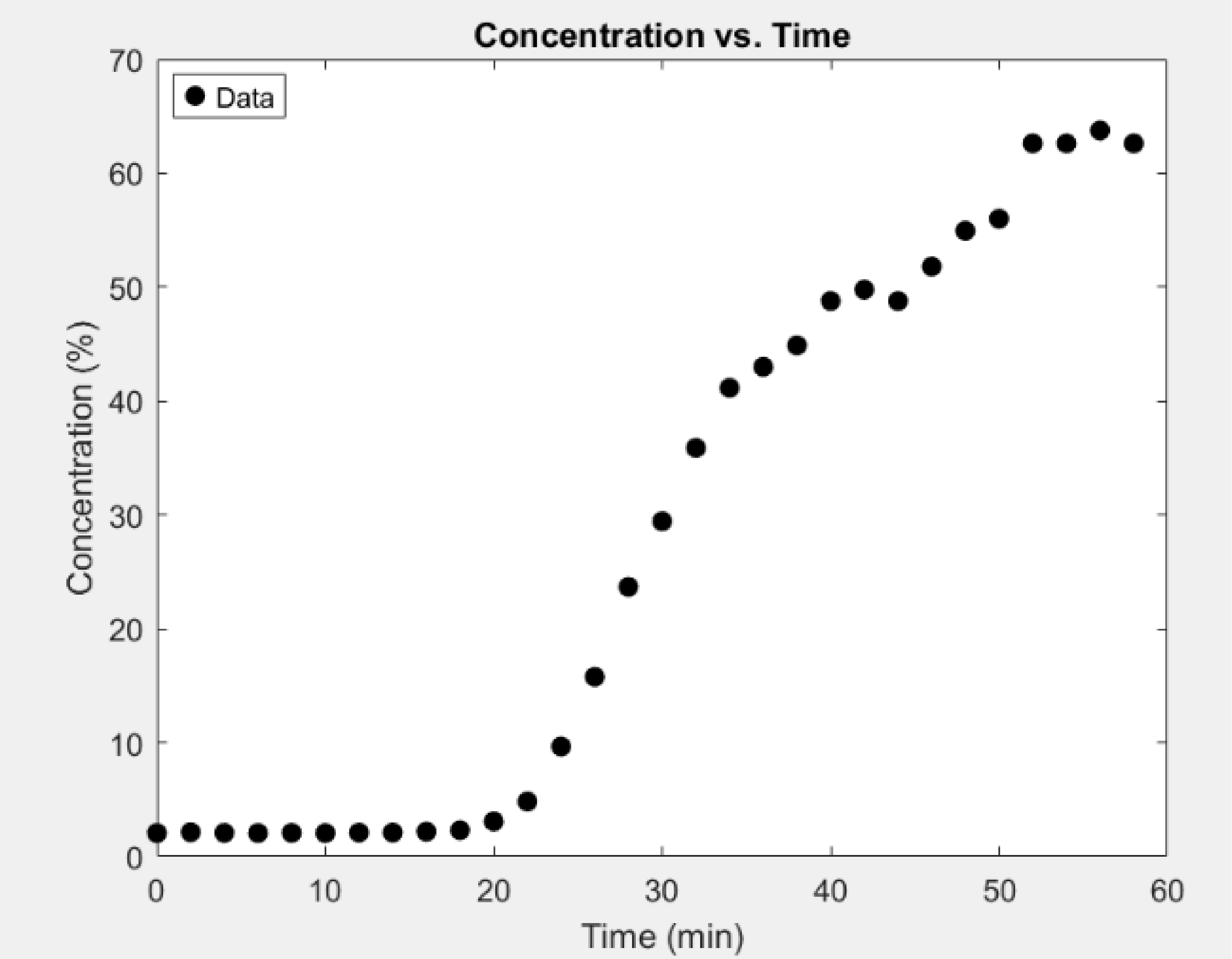
OBSERVATION TABLE

Activated Charcoal Bed

Time(min)	Abs	conc(%)	Time(min)	Abs	conc(%)
0	0	2.061	32	0.80	35.881
2	0.04	2.140	34	0.86	41.154
4	0.02	2.079	36	0.88	42.997
6	0.01	2.065	38	0.90	44.882
8	0.02	2.079	40	0.94	48.779
10	0.01	2.065	42	0.95	49.780
12	0.03	2.104	44	0.94	48.779
14	0.03	2.104	46	0.97	51.813
16	0.05	2.186	48	1.00	54.943
18	0.07	2.310	50	1.01	56.008
20	0.14	3.079	52	1.07	62.617
22	0.23	4.831	54	1.07	62.617
24	0.38	9.661	56	1.08	63.756
26	0.51	15.777	58	1.07	62.617
28	0.64	23.686			
30	0.72	29.444			

OBSERVATIONS

Activated Charcoal Bed



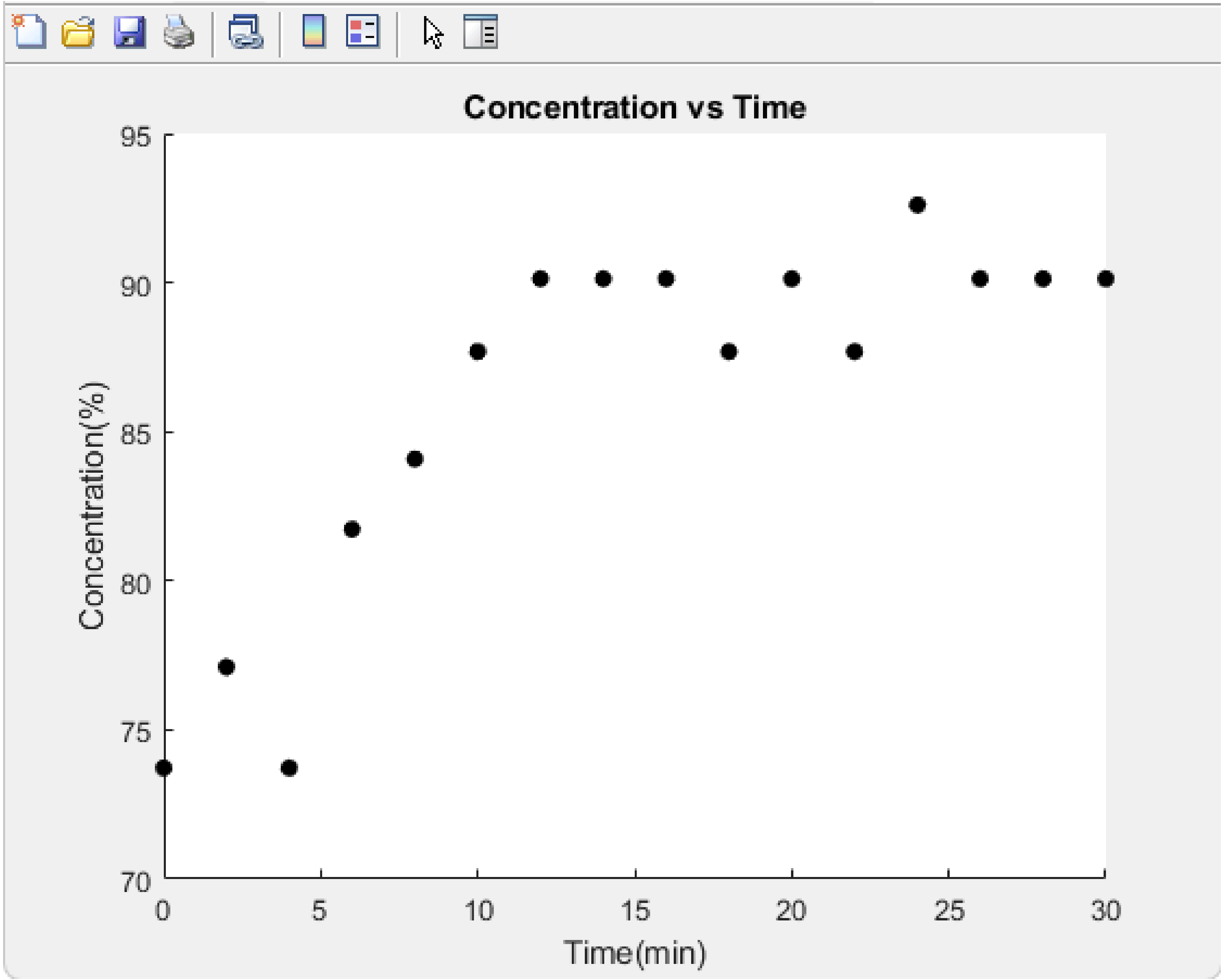
OBSERVATION TABLE

Chalk Bed

Time(min)	Abs(at top)	Abs(in middle)	Time(min)	Abs(at top)	Abs(in middle)
0	1.16	1.09	16	1.26	1.23
2	1.21	1.12	18	1.26	1.21
4	1.26	1.09	20	1.26	1.21
6	1.25	1.16	22	1.26	1.21
8	1.25	1.18	24	1.26	1.25
10	1.25	1.21	26	1.26	1.23
12	1.25	1.23	28	1.26	1.23
14	1.25	1.23	30	1.26	1.23

OBSERVATIONS

Chalk Bed



CALCULATIONS

Activated Charcoal Bed

length of column ⇒

$Z_o = 0.6m$, $t_b = 0$ $\quad t_\delta = 40min$

length of unused bed =

$$LUB = \frac{Z_o}{t_o}(t_o - t_\delta)$$

$$= 0.42m$$

Length of Unused Bed = 0.42m

Chalk Bed

For chalk bed due to poor adsorptivity the perfect breakthrough curve was not observed .
So , a large portion of bed is unused.

OBSERVATIONS

Chalk is a significantly less effective adsorbent than activated charcoal.
This might be due to the following reasons :

- **Less Surface Area** :

Adsorption is a surface phenomenon, meaning the more surface area a material has, the more molecules it can attract and hold.

Chalk: Has a relatively low surface area because its particles are dense and not very porous.

Activated Charcoal: Is made by heating carbon-rich materials at high temperatures, which creates a network of tiny pores, drastically increasing its surface area

- **Shiny (Smooth) Surface** :

A shiny or smooth surface indicates a lack of roughness or porosity, reducing the ability of molecules to "stick" to it.

Chalk: Often has a smoother and more crystalline surface, leading to fewer binding sites for adsorbate molecules.

Activated Charcoal: Has a rough, porous, and matte surface, ideal for trapping molecules in its tiny cavities.

CONCLUSION

Activated charcoal, owing to its highly porous structure and significantly larger surface area, is expected to adsorb more $KMnO_4$ compared to chalk, which has a relatively lower surface area.

This illustrates the role of surface area and porosity in determining the adsorption capacity of different materials.

A **microporous adsorbent** and a **true solution** as feed ensures efficient solid-liquid adsorption.

THANK YOU

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