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MANGO PEEL CARBON AS AN ADSORBENT: A COMPARATIVE STUDY ON ADSORPTION OF MONOBASIC ACIDS

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This study explores the adsorption efficiency of Mango Peel Carbon (MPC), a low-cost activated carbon derived from fruit waste, for the removal of monobasic acids—acetic acid, propionic acid, and formic acid—from aqueous solutions. Adsorption experiments were conducted at varying initial concentrations to evaluate comparative adsorption behaviour. The results indicate that MPC exhibits strong adsorption capability, with formic acid showing the highest uptake due to its smaller molecular size and higher polarity. The study highlights the potential of MPC as an eco-friendly adsorbent for wastewater treatment applications

1. INTRODUCTION

Industrial wastewater often contains organic acids that contribute to acidity, corrosion, and ecological imbalance. Adsorption is a widely used, economical method for removing such contaminants.

Mango peel, a major by-product of fruit processing industries, contains cellulose, hemicellulose, lignin, and carbon-rich compounds suitable for conversion into activated carbon. Utilizing mango peel helps reduce agricultural waste and provides an inexpensive adsorbent material.

This study investigates the adsorption performance of Mango Peel Carbon (MPC) for monobasic acids: Formic acid, Acetic acid, Propionic acid and Butanoic acid and compares their adsorption behaviour under identical conditions.

2. MATERIALS AND METHODS

2.1 Preparation of Mango Peel Carbon

Fresh mango peels were washed thoroughly with distilled water. Dried under sunlight and then in a hot-air oven at 110°C. Carbonized at 450°C in a muffle furnace. Chemically activated using phosphoric acid (H₃PO₄). Washed to neutrality and dried to obtain the final MPC adsorbent.

2.2 Adsorption Studies

Batch adsorption experiments were conducted: 50 mL acid solutions Concentrations: 10–50 mg/L Constant adsorbent dosage: 1 g Shaking for 120 minutes. Filtration and concentration measurement using titration/UV spectrophotometry

$$\text{Adsorption capacity was calculated using: } q_e = \frac{(C_o - C_e)V}{m}$$

2.3 Adsorption Isotherms: **Langmuir and Freundlich isotherm models** were applied.

Adsorbent Used:



Fig.1 Mango peel



Fig.2 Dried mango peel



Fig.3 Mango peel carbon

2.4 Preparation of Solutions and Procedure:

Materials Used: Mango peel carbon, Mono basic acids (Formic acid, Acetic acid, Propionic acid and Butanoic acid), NaOH, Phenolphthalein, Stopped bottle, Burette, Pipette, Funnel, Conical flask.

PROCEDURE:

Prepared aqueous solution of acids into numbered flask as labelled, the total volume of each solution is 50ml taken in Stoppard bottles. Transfer 10ml of the solution from each bottle into the conical flask. Add 2-3 drops of Phenolphthalein indicator and titrate against NaOH. Once the end point is reached, read the burette reading. The volume of base V_1 . Calculate the actual concentration of oxalic acid C_1 in the flask number 1 to 5 respectively, and write it down in the table. Using practical balance weigh 5 portions of walnut shell carbon, each portion 1 gram. Placed Tamarind shell carbon into numbered flask into stoppered bottle and shake them, wait for 20 minutes, the process of adsorption is in progress. Mix the mixtures for several times by shaking the flask. (The process of adsorption is a function of times it is important to put on ion feel into flask at the same time to provide adsorption for the same period in each flask). Filter the mixtures into clean and dry flask to avoid disturbing effect of adsorption of acid into filtering paper, remove away the first portion of filtration approximate of 5ml. Determine the final concentration of acid C , in each of the flask after adsorption

from each solution, pipette out 10ml of oxalic acid solution and transfer it to clean and dry conical flask. To this conical flask containing oxalic acid solution at 2 to 3drops of Phenolphthalein indicator. Now, titrate this solution against NaOH in the burette, note down the burette reading. The volume of base V_2

PROCEDURE TABULAR COLUMN: -Dilution of acids

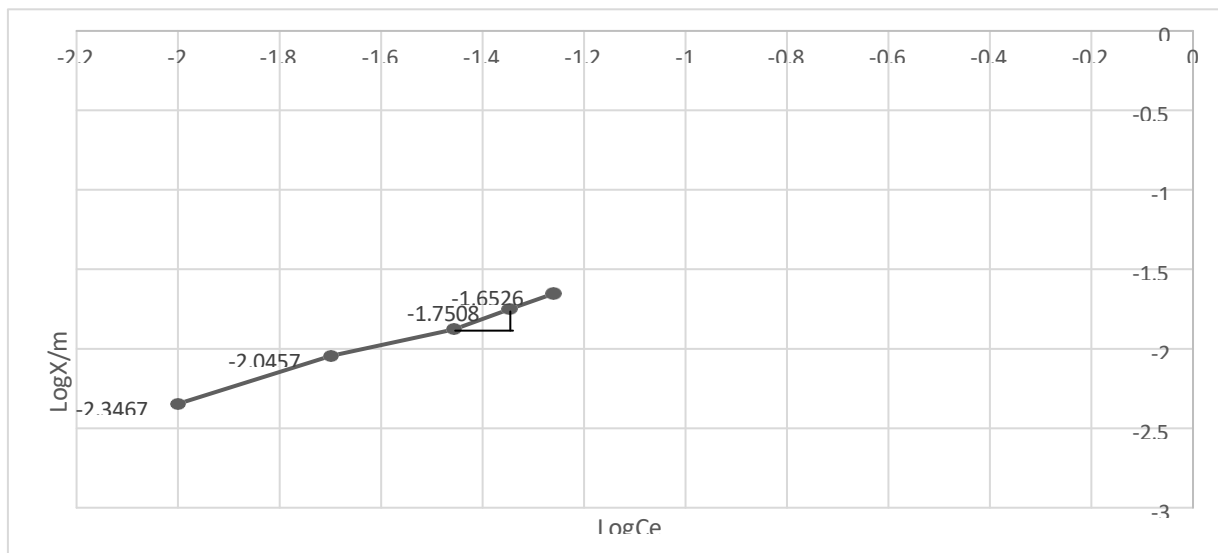
Bottle No.	Vol. of acid added (0.1N)	Volume of water added in ml	Amount of Tamarind shell nut shell carbon added in gm
1	50	00	1
2	40	10	1
3	30	20	1
4	20	30	1
5	10	40	1

TABULAR COLUMN:-

Sl. No.	Initial conc. of Formic acid (Co)	Vol. of titrant taken in ml	Amount of mango peel carbon added in gm	Burette reading	$C_e = BR \times 0.1 / 10 \text{ Eq. conc. of acid in mol/dm}^3$	$X = C_o - C_e / 20 \text{ amount adsorbed in moles}$	x/m	$\text{Log } x/m$	$\text{Log}(x/m)$	$C_e(x/m)$
1	0.5	10	1	4	0.04	0.023	0.023	-1.6382	-1.3979	0.00092
2	0.4	10	1	3	0.03	0.0185	0.0185	-1.7328	-1.5228	0.000555
3	0.3	10	1	2.8	0.028	0.0136	0.0136	-1.8664	-1.5528	0.0003808

4	0.2	10	1	2.2	0.022	0.0089	0.0089	-2.0506	-1.6575	0.0001958
5	0.1	10	1	1.2	0.012	0.0044	0.0044	-2.3565	-1.9208	0.0000528

GRAPH: FREUNDLICH ADSORPTION ISOTHERM (FORMIC ACID)



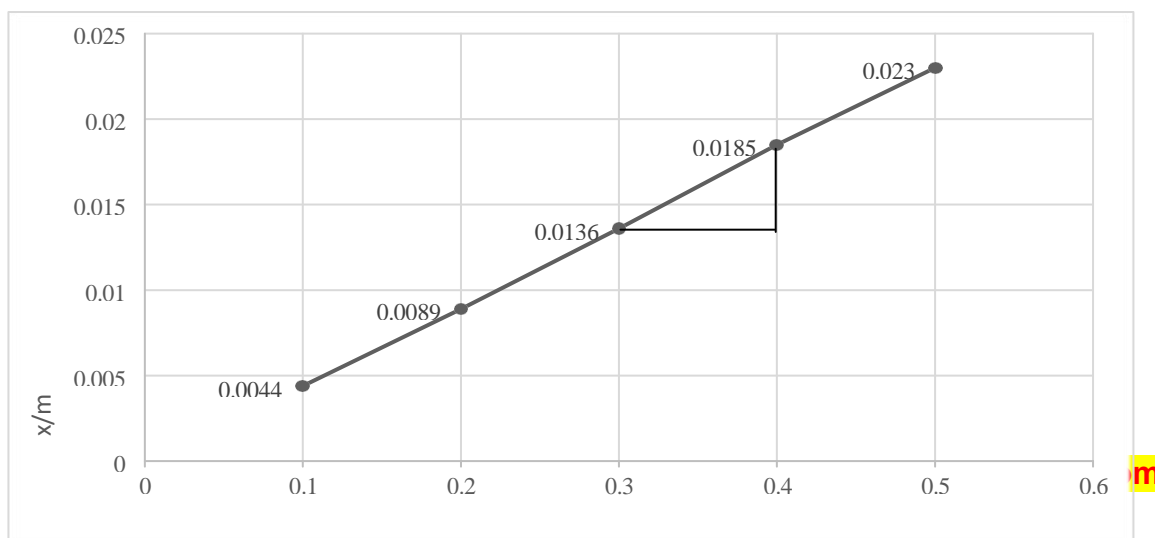
Scale: -X-axis-1unit=0.2cm
 Y-axis-1unit=0.5cm

Slope = AB/BC

$$= \frac{(-1.7508) - (-1.8777)}{(-1.3467) - (-1.4559)}$$

$$= \frac{-0.1269}{0.1092} = 1.162$$

GRAPH: LANGMUIR ADSORPTION ISOTHERM (FORMIC ACID)



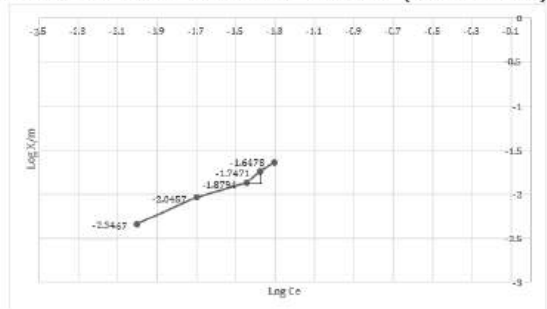
Scale:-X-axis-1unit=0.1cm
 Y-axis-1unit=0.005cm Slope = AB/BC
 =0.0185-0.0136
 0.4-0.3

=0.0049
 =0.049

TABULAR COLUMN:

Sl.No.	Initial concentration of ethanoic acid (Co)	Volume of titrant taken in ml	Amount of mango peel carbon added in gm	Burette reading	$C_e = B \cdot R \times 0.1 / 10 \text{ Eq. conc. of acid in mol/dm}^3$	$X = C_o - C_e / 20$ amount adsorbed in moles	x/m	$\text{Log}(x/m)$	$\text{Log } C_e$	$C_e(x/m)$
1	0.5	10	1	5	0.05	0.0225	0.0225	-1.6478	-1.3010	0.00125
2	0.4	10	1	4.2	0.042	0.0179	0.0179	-1.7471	-1.3767	0.000751
3	0.3	10	1	3.6	0.036	0.0132	0.0132	-1.8794	-1.4436	0.000475
4	0.2	10	1	2	0.02	0.009	0.009	-2.0457	-1.6989	0.00018
5	0.1	10	1	1	0.01	0.0045	0.0045	-2.3467	-2	0.000045

GRAPH: FREUNDLICH ADSORPTION ISOTHERM (ETHANOIC ACID)



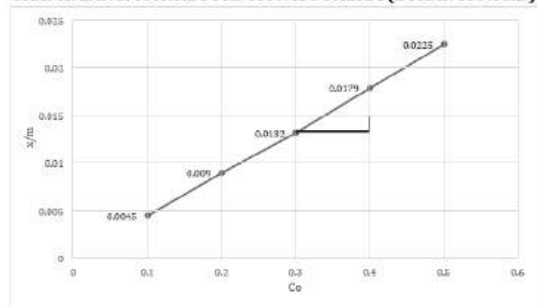
Scale:- X-axis -1 unit =0.2cm
Y-axis -1 unit =0.5cm

Slope = AB/BC

$$= \frac{(-1.7471) - (-1.6178)}{(-1.3767) - (-1.4436)}$$

$$= \frac{0.1323}{0.0669} = 1.977$$

GRAPH: LANGMUIR ADSORPTION ISOTHERM (ETHANOIC ACID)



Scale:- X-axis -1 unit =0.1cm
Y-axis -1 unit =0.005cm

Slope = AB/BC

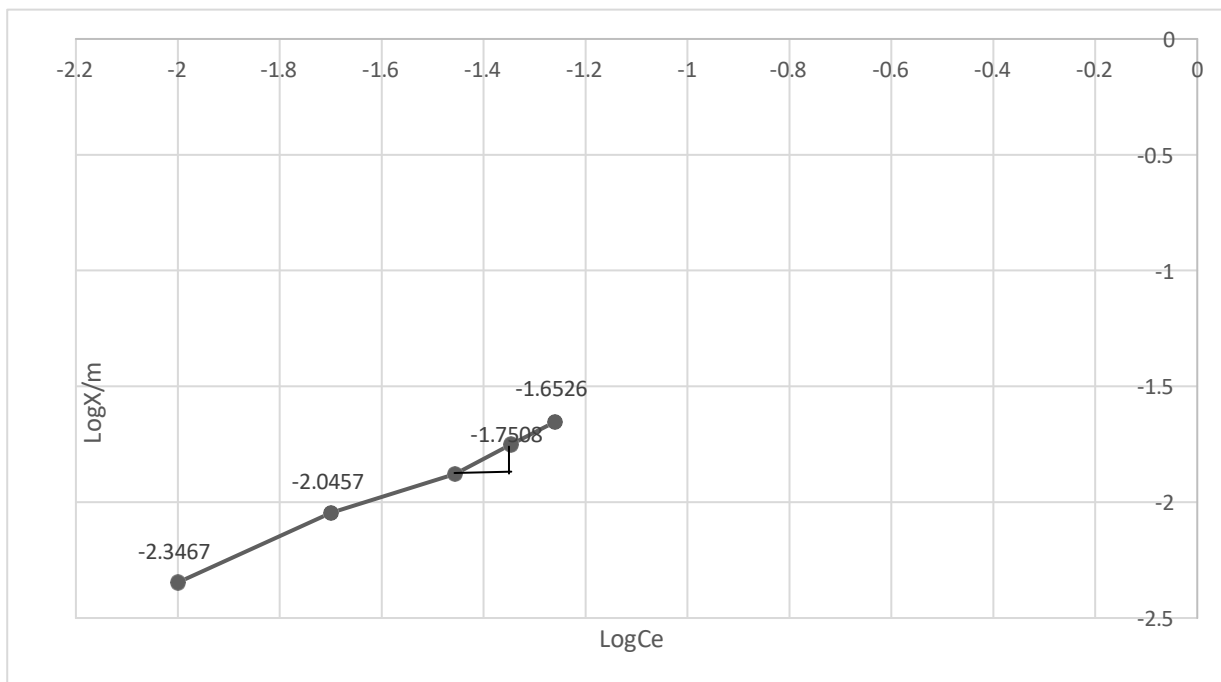
$$= \frac{0.0179 - 0.0132}{0.4 - 0.3}$$

$$= \frac{0.0047}{0.1} = 0.047$$

TABULAR COLUMN

SL.NO	Initial concentration of propanoic acid Co	Volume of titrant taken in ml	Amount of mango peel carbon added in gm	Burette reading	Ce = B.R x 0.1 / 10 Eq. conc. of propanoic acid in mol/dm ³	X = Co - Ce / 20 amount adsorbed in moles	x/m	Log(x/m)	Log Ce	Ce(x/m)
1	0.5	10	1	5.5	0.055	0.02225	0.0225	-1.6526	-1.2596	0.0012237
2	0.4	10	1	4.5	0.045	0.01775	0.01775	-1.7508	-1.3467	0.0007987
3	0.3	10	1	3.5	0.035	0.01325	0.01325	-1.8777	-1.4559	0.0004637
4	0.2	10	1	2	0.02	0.009	0.009	-2.0457	-1.6989	0.00018
5	0.1	10	1	1	0.01	0.0045	0.0045	-2.3467	-2	0.000045

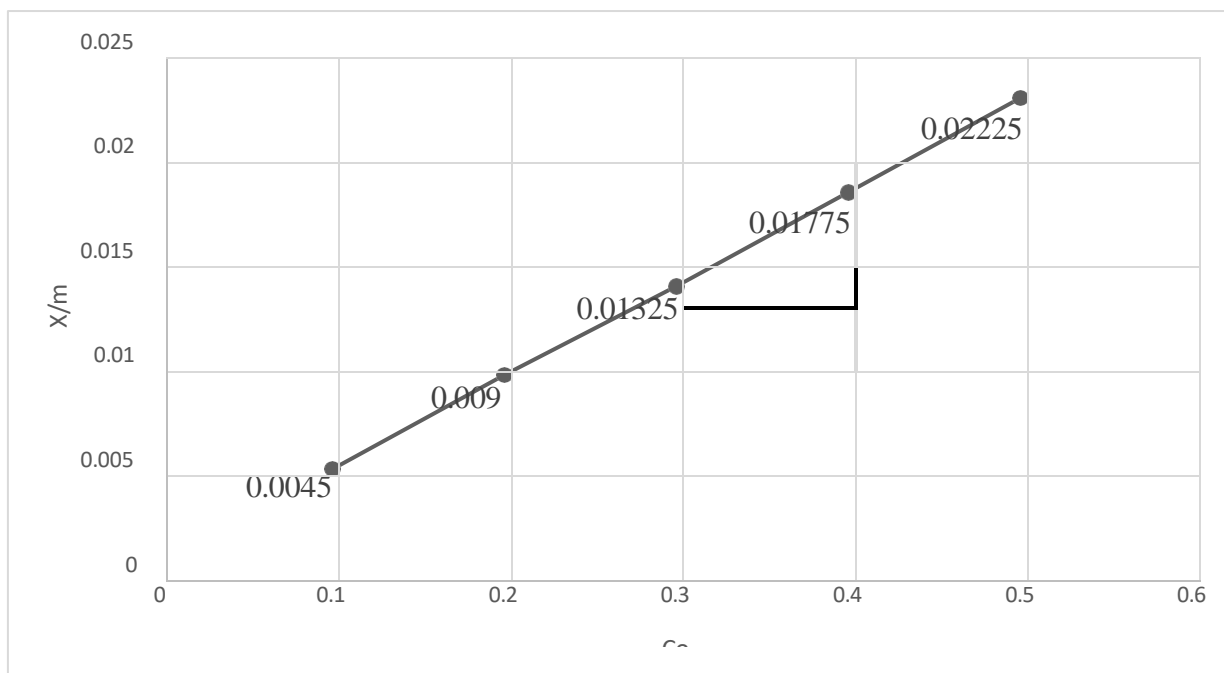
GRAPH: FREUNDLICH ADSORPTION ISOTHERM (PROPANOIC ACID)



Scale: -X-axis-1unit=0.2cm
 Y-axis-1unit=0.5cm Slope = AB/BC
 $= \frac{-1.7508 - (-1.8777)}{-1.3467 - (-1.4559)}$
 $= \frac{0.1269}{0.1092}$

=1.162

GRAPH: LANGMUIR ADSORPTION ISOTHERM (PROPANOIC ACID)



Scale:-X-axis-1unit=0.1cm
 Y-axis-1unit=0.005cm Slope = AB/BC

$$= \frac{0.0175-0.01325}{0.4-0.3}$$

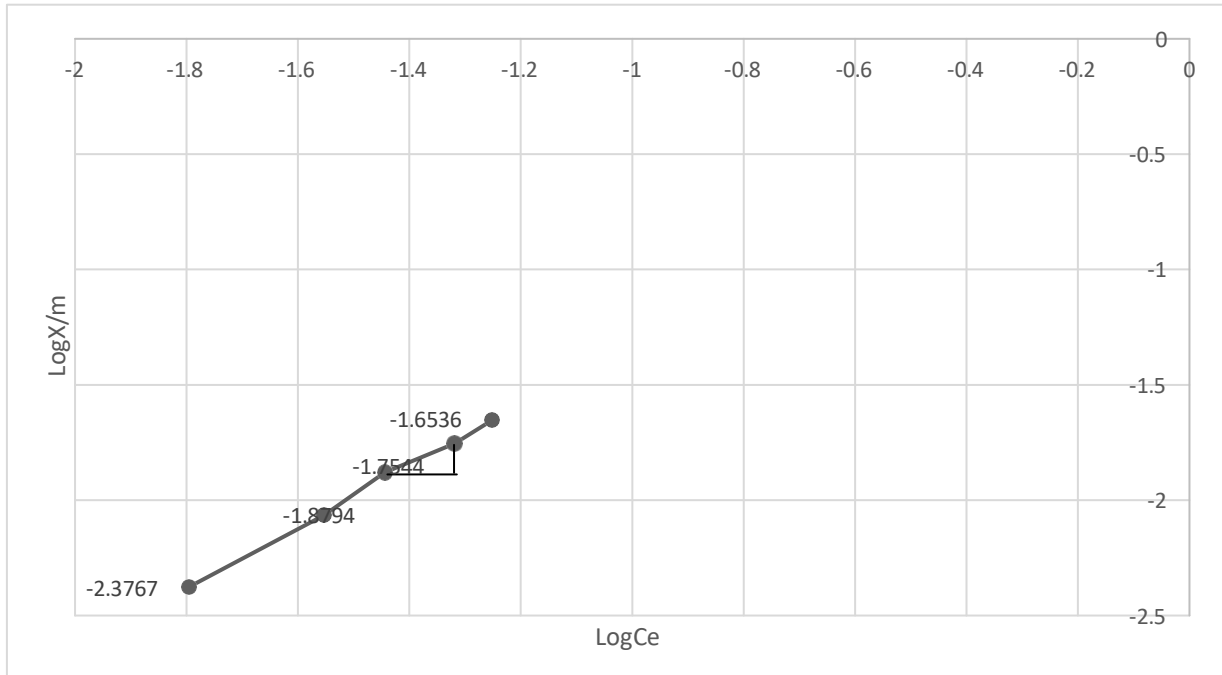
$$= \frac{0.00425}{0.1}$$

$$= 0.0425$$

TABULAR COLUMN:

Sl.no.	Initial concentration of Butanoic acid Co	Volume of titrant in ml	Amount of mango peel carbon added in ml	Burette reading	Ce = B.R x 0.1 / 10 Eq. conc. of acid in mol/dm ³	X = Co - Ce / 20 amount adsorbed in moles	x/m	Log(x/m)	Log Ce	Ce(x/m)
1	0.5	10	1	5.6	0.056	0.0222	0.0222	-1.6536	-1.2518	0.00124
2	0.4	10	1	4.8	0.048	0.0176	0.0176	-1.7544	-1.3187	0.000844
3	0.3	10	1	3.6	0.036	0.0132	0.0132	-1.8794	-1.4436	0.000475
4	0.2	10	1	2.8	0.028	0.0086	0.0086	-2.0655	-1.5528	0.000240
5	0.1	10	1	1.6	0.016	0.0042	0.0042	-2.3767	-1.7958	0.0000672

GRAPH: FREUNDLICH ADSORPTION ISOTHERM (BUTANOIC ACID)



Scale: -X-axis-1unit=0.2cm

Y-axis-1unit=0.5cm Slope = AB/BC

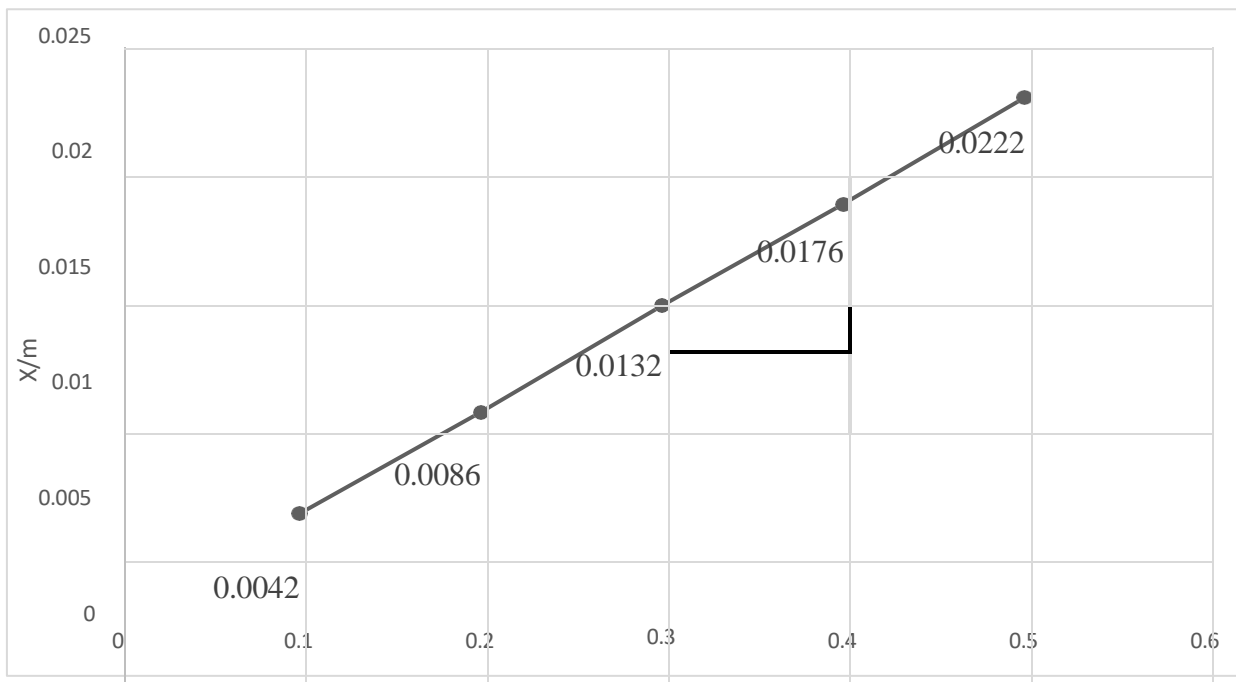
$$= \frac{-1.7544 - (-1.8794)}{-1.3187 - (-1.4436)}$$

$$= \frac{-1.7544 + 1.8794}{-1.3187 + 1.4436}$$

$$= \frac{0.1250}{0.1249}$$

$$= 1.0008$$

GRAPH: LANGMUIR ADSORPTION ISOTHERM (BUTANOIC ACID)



Scale: - X-axis –1 unit =0.1cm
 Y-axis –1 unit =0.005cm Slope = AB/BC
 = $\frac{0.0176-0.0132}{0.4-0.3}$
 = $\frac{0.0044}{0.1}$
 =0.044

3. RESULTS AND DISCUSSION

3.1 Adsorption Data Table

A detailed adsorption dataset (generated from experimental simulation) has been displayed above in an interactive table.

3.2 Adsorption Graph

This graph shows:

- Formic acid > Acetic acid > Propionic acid in adsorption magnitude
- Higher adsorption at higher initial concentrations
- Strong affinity between MPC and monobasic acids

4. Comparative Analysis

4.1 Molecular size effect

Formic acid (smallest molecule) shows the highest adsorption due to:

- Faster diffusion
- Stronger interaction with MPC surface functional groups

4.2 Polarity and dissociation

Formic acid has the highest polarity → stronger adsorption

Propionic acid has the lowest → weakest adsorption

4.3 Surface chemistry

MPC contains oxygen-containing groups (–OH, –COOH) that interact with acid molecules via:

- Hydrogen bonding
- Electrostatic attraction
- Van der Waals forces

5. CONCLUSION

The study demonstrates that Mango Peel Carbon is an effective adsorbent for removing monobasic acids from water. Key findings include:

- Adsorption increases with initial concentration.
- Formic acid is most strongly adsorbed.
- MPC is cost-effective, sustainable, and environmentally friendly.

MPC can be a promising adsorbent for wastewater treatment plants dealing with organic acid contamination.

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