

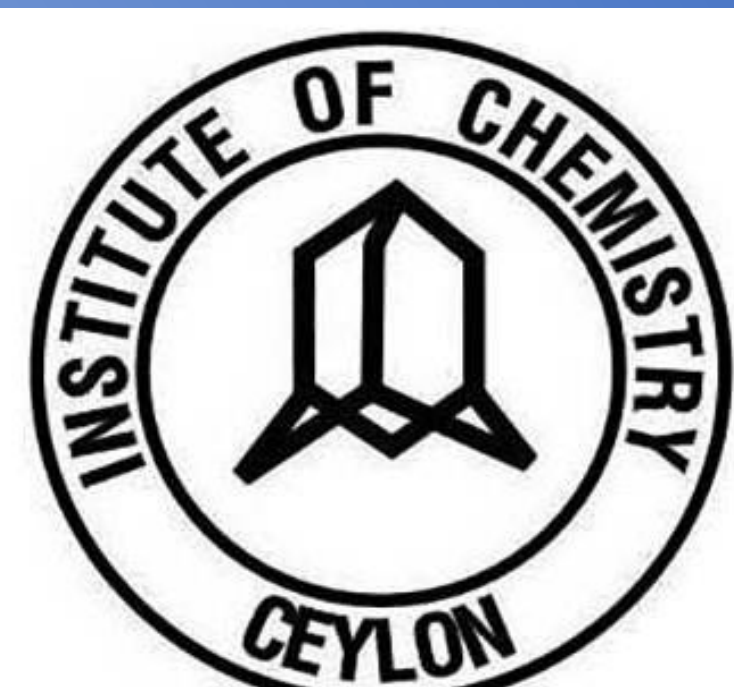


Environmentally Friendly Method to Remediate Industrial Wastewater Using Banana Pseudo Stem Biomass (BPSB)

An Alternative to Activated Charcoal (AC)

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Introduction

- Environmental pollution is one of the most challenging issues due to emerging industries.
- Textile industry is one of such which disposes significant quantities of chemicals that causes water pollution with an irreversible damage to the ecosystem.
- Effluents from textile industries contain dyes which are toxic, mutagenic, and sometimes carcinogenic to the aquatic and human health.
- Various methods including adsorption have been tested for the removal of dyes from industrial effluents.
- Activated charcoal/carbon (AC) is widely used as one of the most effective adsorbents in wastewater treatment.
- However, manufacturing cost of AC limits its usage regardless of the demand.
- Therefore, adsorbents derived from agricultural waste, which are economically feasible and environmental friendly, are tested.
- The use of banana pseudo stem biomass (BPSB) is tested as a promising candidate as an alternative to AC in this study.

Research Objectives

- To investigate the feasibility of BPSB as an alternate to AC to remove industrial dyes from aqueous solutions.
- To study BPSB adsorption obeys isotherms, thermodynamics and kinetics.

Methodology

Preparation of adsorbents and adsorbates

BPSB samples (4 varieties) were collected from the North Western Province, Sri Lanka.

Two dyes were purchased from Sisco Research Laboratories (Pvt) Ltd. Mumbai, India.

Samples were sundried for 5 days and oven dried at 60°C for 1 day

Dried pieces were grinded into powder (0.1 – 0.5 mm), sieved, and stored in air tight packages until further use

Powdered samples were washed with distilled water and dried before analysis

A 1250 ppm solution of methylene blue (MB) was prepared (Dissolved 1.250 g of MB in 1 L of deionized water)

A 50 ppm rhodamine B (RHB) solution was prepared (Dissolved 50 mg of RHB in 1 L of deionized water)

Initial pH of MB and RHB solutions were 5.6 and 4.9, respectively

- Samples were named as N₁-Embul (*Musa ochracea*), N₂-Ambun (*Musa acuminata colla*), N₃-Kolikuttu (*Musa acuminata balbisiana*), N₄-Seenikehel (*Musa acuminata Musa balbisiana*) and N₅-Activated Charcoal (control sample)

Adsorption batch studies

Initial Dye Concentration

Contact time

pH

Temperature

Amount of adsorbent

Results Of Adsorption Kinetics (AK) Studies

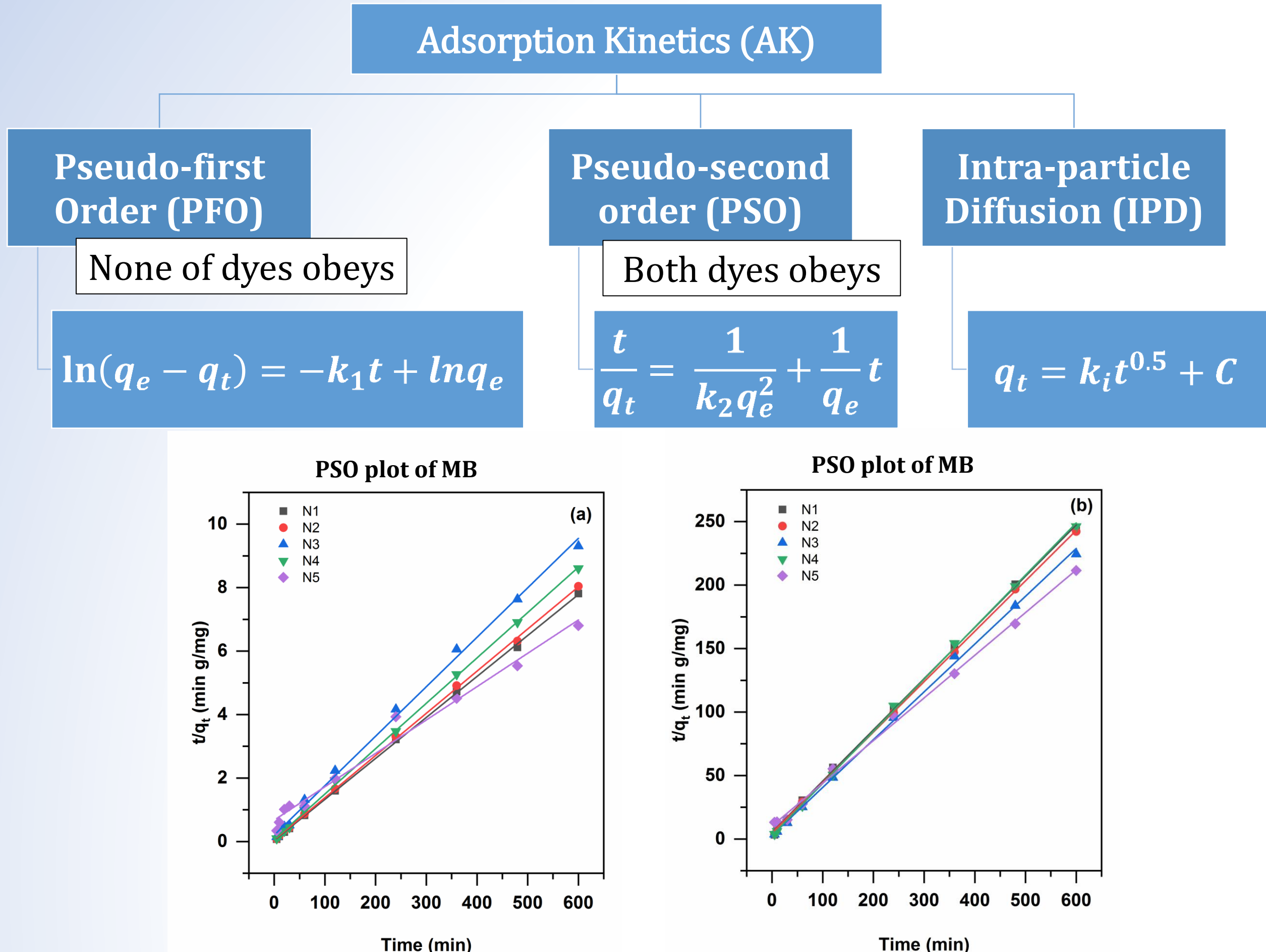


Figure 1. PSO kinetics for adsorption of (a) MB (750 ppm) and (b) RHB (25 ppm) onto 200 mg of BPSB sorbent samples and AC at 30 °C.

Table 1. Comparison of PSO kinetic for adsorption of (a) MB (750 ppm) and (b) RHB (25 ppm) onto 200 mg of BPSB sorbent samples and AC at 30 °C.

Sample	MB				RHB			
	q _e (mg/g)	k ₂ (g/mg min)	R ²	Exp. q _e (mg/g)	q _e (mg/g)	k ₂ (g/mg min)	R ²	Exp. q _e (mg/g)
N ₁	77.459	0.005	0.999	77.329	2.478	0.039	0.999	2.791
N ₂	75.358	0.003	0.999	76.357	2.518	0.033	0.999	2.767
N ₃	64.185	0.001	0.997	60.515	2.657	0.048	0.998	2.746
N ₄	69.979	0.003	0.999	68.366	2.437	0.062	0.999	2.759
N ₅	95.147	0.0002	0.980	60.646	2.975	0.011	0.997	2.172

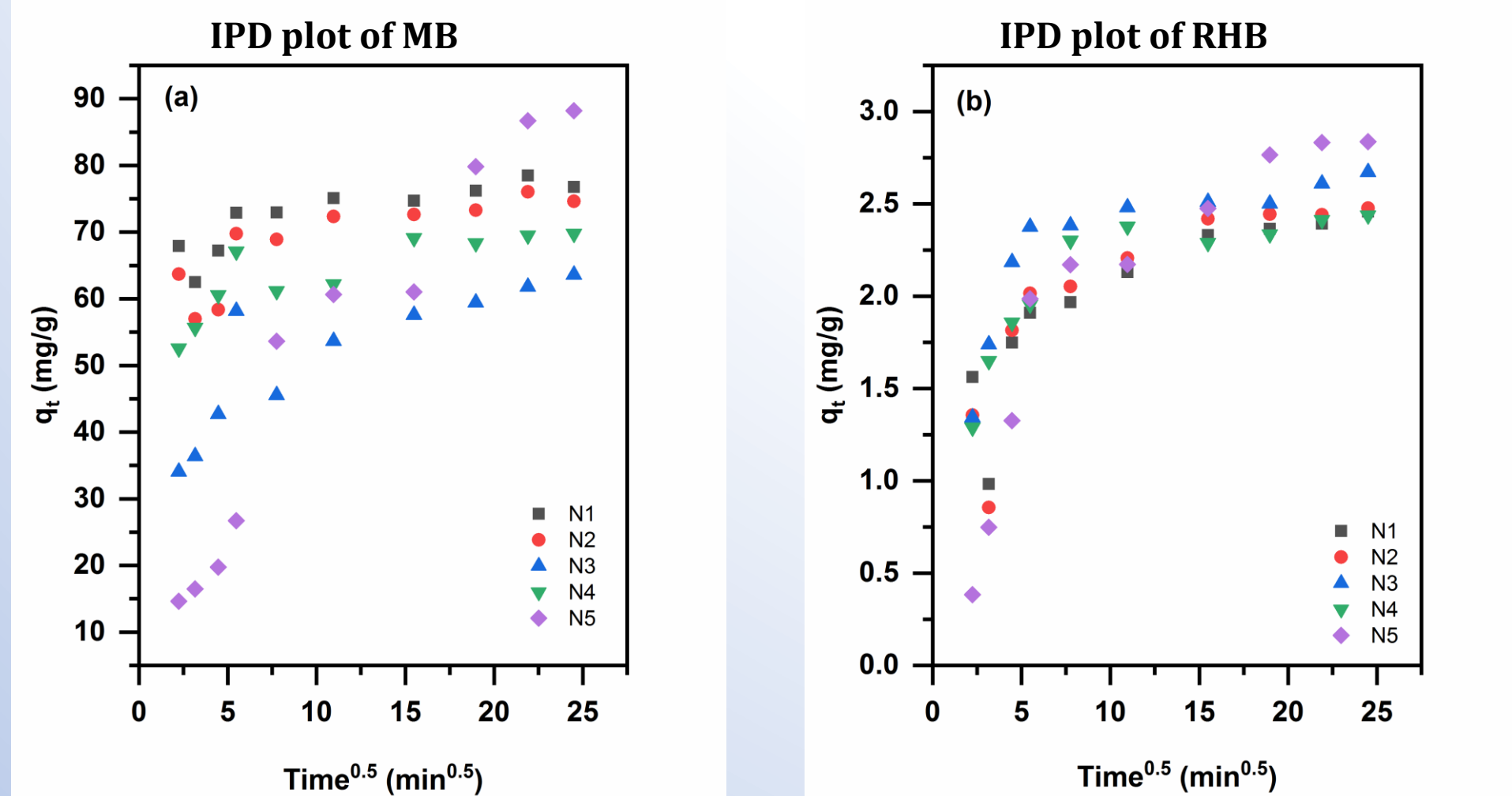


Figure 2. Intraparticle diffusion (a) MB and (b) RHB.

Results Of Adsorption Isotherm (AI) Studies

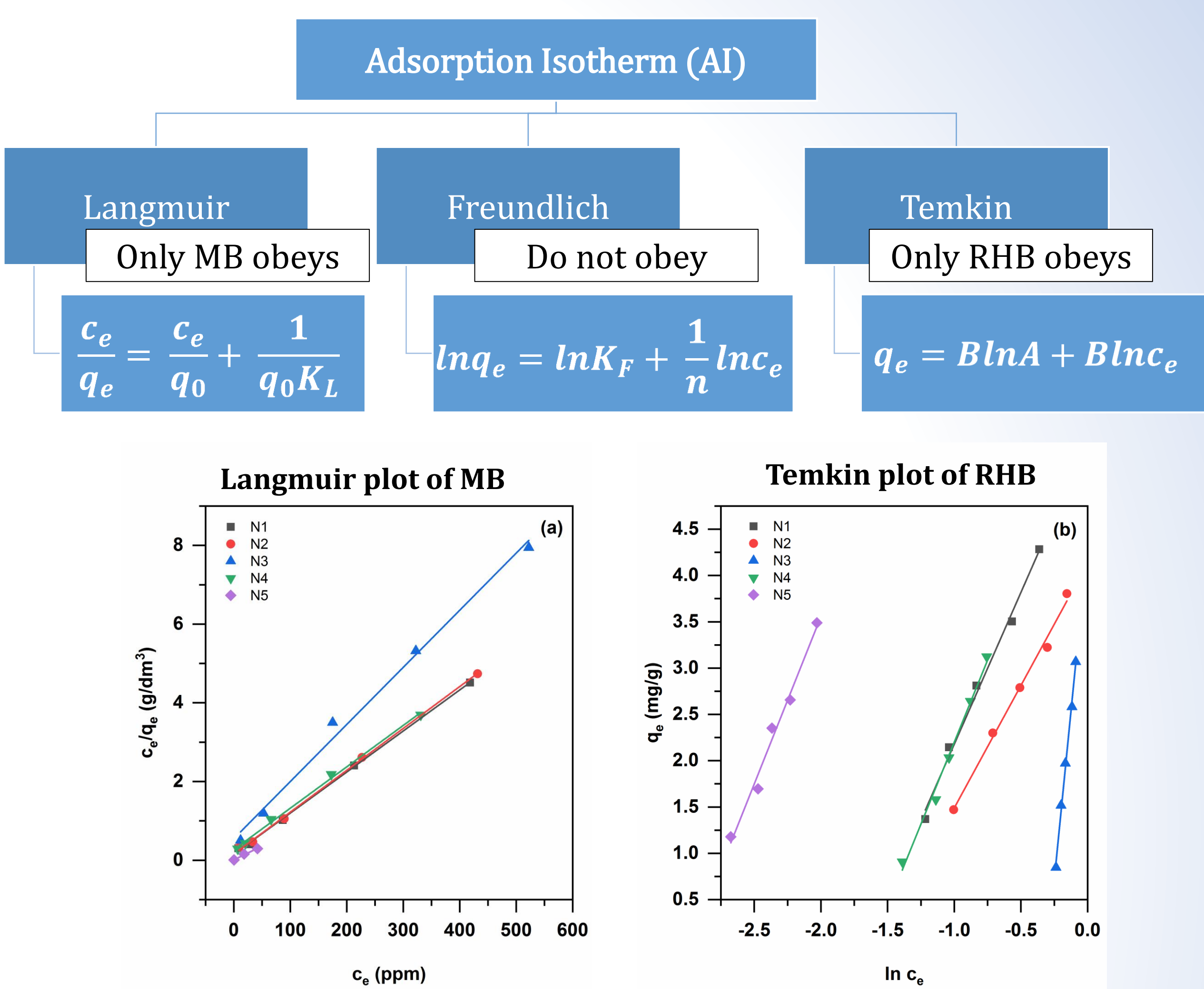


Figure 3. Langmuir and Temkin adsorption isotherm for (a) MB and (b) RHB onto BPSB sorbent samples at 30 °C.

Table 2. Isotherm parameters for removal of MB onto 200 mg of BPSB sorbent samples and AC at 30 °C.

Isotherm	N ₁	N ₂	N ₃	N ₄	N ₅
Langmuir					
K _L (dm ³ mg ⁻¹)	6.8 × 10 ⁻²	6.7 × 10 ⁻²	2.7 × 10 ⁻²	3.9 × 10 ⁻²	0.86
q _{max} (mg g ⁻¹)	95.88	93.98	68.92	95.06	141.64
R _L	0.057	0.051	0.131	0.093	0.005
R ²	0.998	0.998	0.990	0.996	0.990
Freundlich					
R ²	0.670	0.679	0.931	0.909	0.713
Temkin					
R ²	0.779	0.776	0.967	0.989	0.862

Acknowledgement

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Table 3. Isotherm parameters for removal of RHB onto 200 mg of BPSB sorbent samples and AC at 30 °C.

Isotherm	N ₁	N ₂	N ₃	N ₄	N ₅
Langmuir					
R ²	0.111	0.167	0.745	0.822	0.681
Freundlich					
R ²	0.929	0.969	0.923	0.986	0.960
Temkin					
B _T (J mol ⁻¹)	3.65	2.34	18.30	18.23	19.23
A _T (L mg ⁻¹)	4.47	5.87	1.27	1.37	1.81
R ²	0.990	0.991	0.993	0.987	0.979

Discussion

- Concentration studies demonstrated higher adsorption capacities (q_e) with all BPSB varieties compared to AC except at lower concentrations.
- The pH, temperature, adsorbent dosage, and contact time optimizations studies also demonstrated comparable or higher q_e values which showed that BPSB is a promising candidate in the dye removal process.
- Experimental data were demonstrated that both MB and RHB adsorptions obeyed PSO kinetics with $R^2 > 0.999$ for all BPSB and AC.
- Data fittings suggested that MB adsorption onto BPSB obeyed the Langmuir isotherm while RHB onto BPSB obeyed the Temkin isotherm with $R^2 > 0.999$ for all BPSB and AC.
- Since both q_t versus $t^{1/2}$ graphs did not pass through the origin, the intraparticle diffusion was not the rate limiting step in either processes.
- Therefore, it can be concluded that external mass transfer on to the BPSB may also be significant in the sorption process.

Conclusion

- This study demonstrated that a common agricultural waste, BPSB, can be transformed to an efficient sorbent for the removal of MB and RHB from aqueous solution.
- The results were comparable and better than more costly adsorbent activated carbon which is promising.
- Kinetic studies demonstrated that adsorption of MB and RHB onto the BPSB obeyed the PSO kinetics.
- Equilibrium studies demonstrated that the Langmuir isotherm had the best correlation for MB adsorption onto BPSB while Temkin isotherm had the best correlation for the adsorption of RHB onto BPSB.

References

- Langmuir, I. The Adsorption of Gases on Plane Surfaces of Glass, Mica, and Platinum. *J. Am. Chem. Soc.* **1918**, 40 (9), 1361–1403.
- Ofomaja, A. E. Kinetics and mechanism of methylene blue sorption onto palm kernel fibre, *Process Biochem.* **2007**, 42, 16–24.
- Hameed, B. H. Spent Tea Leaves: A New Non-Conventional and Low-Cost Adsorbent for Removal of Basic Dye from Aqueous Solutions. *J. Hazard. Mater.* **2009**, 161 (2–3), 753–759.