# Supplementary File

# Supporting Information (SI)

*Research Article*

## *Industrial-scale Feasibility for Textile wastewater Treatment via photocatalysis-adsorption technology using (Black Sand& UV Lamp)*

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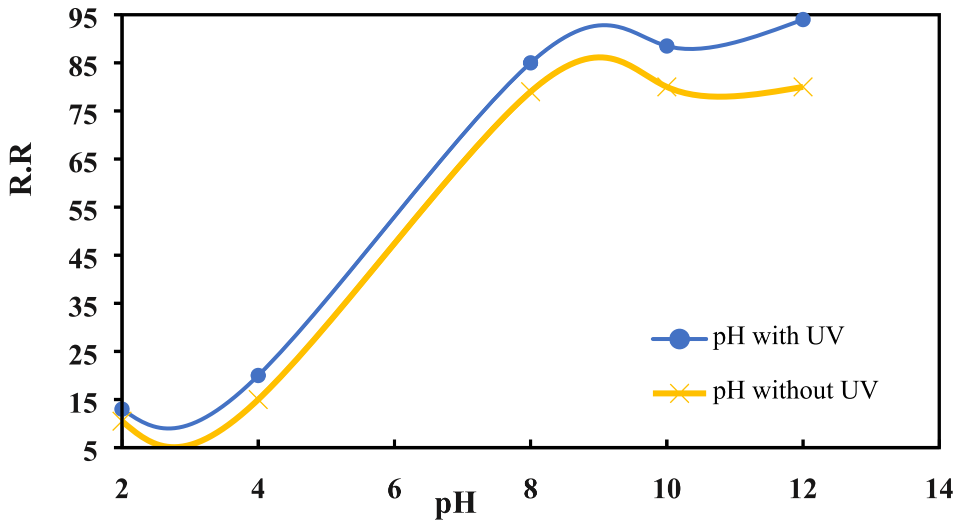


**Fig S1**. Effect of pH on MB removal by black sand assisted with and without UV lamp at bed height = 15 cm, flow rate = 53.33 mL/min, initial MB concentration = 100 ppm

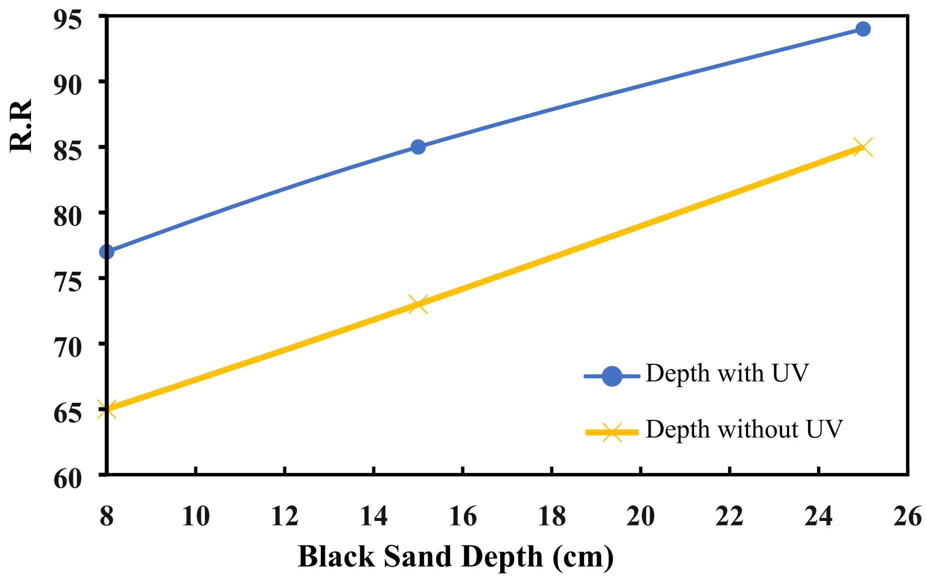


**Fig. S2**. Effect of Black Sand Depth on Black Sand assisted with& without UV Lamp at pH = 10, flow rate = 53.33 mL/min, initial MB concentration = 100 ppm.

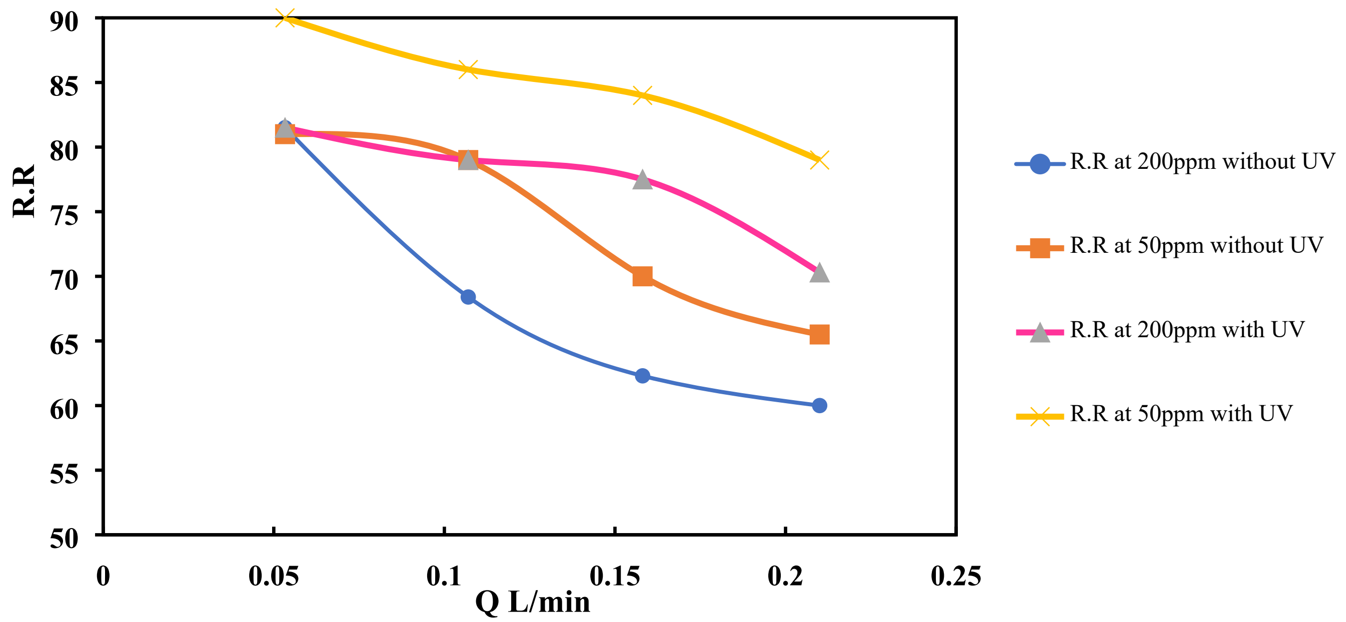


**Fig.S3.** Effect of Flowrate on Black Sand at Two MB Conc. Assisted with & without UV Lamp UV Lamp at Different Dye Conc. (200 ppm), pH (10), Black Sand Depth (15 cm).

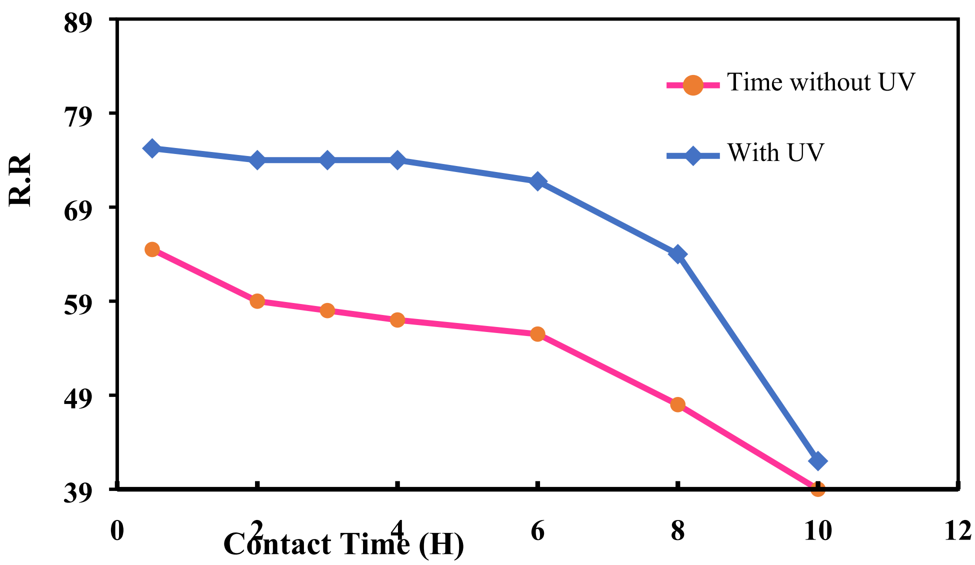


**Fig.S4.** Effect of Contact Time on Black Sand assisted with& without UV Lamp at pH = 10, Black Sand Depth (15 cm). initial MB concentration = 100ppm).

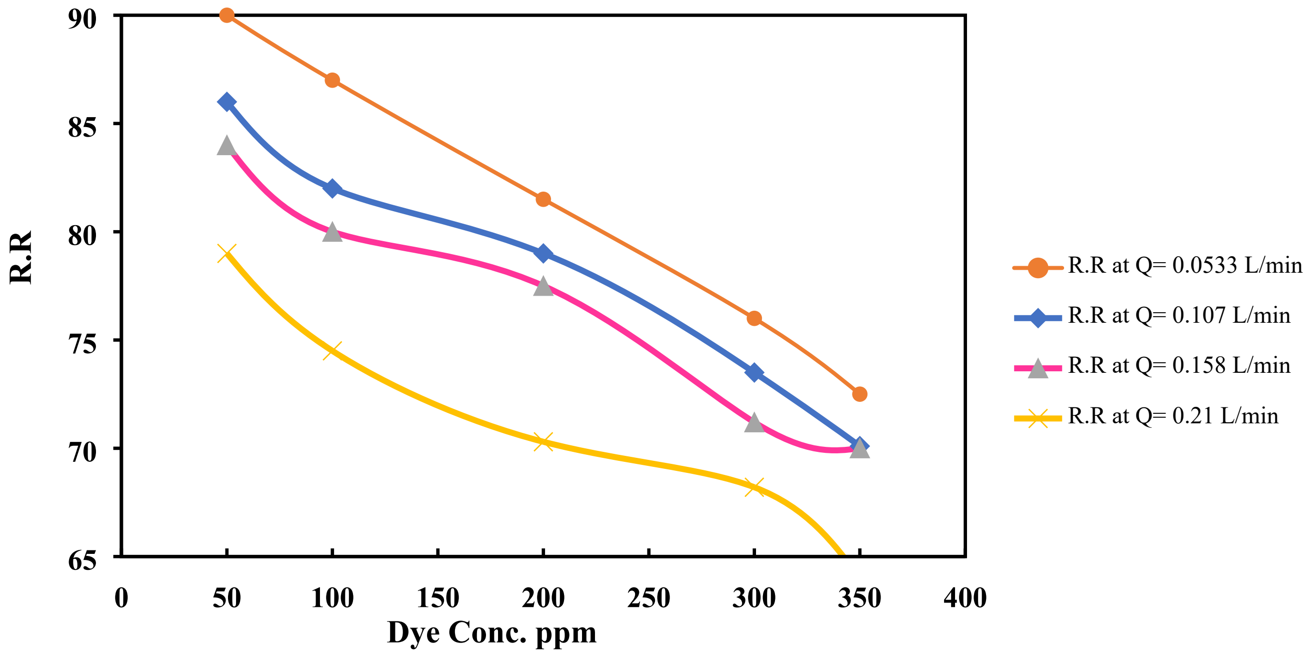


**Fig.S5.** Effect of Dye Conc. on Black Sand assisted with UV Lamp at pH = 10, Black Sand Depth (15 cm).initial MB concentration = 100 ppm).

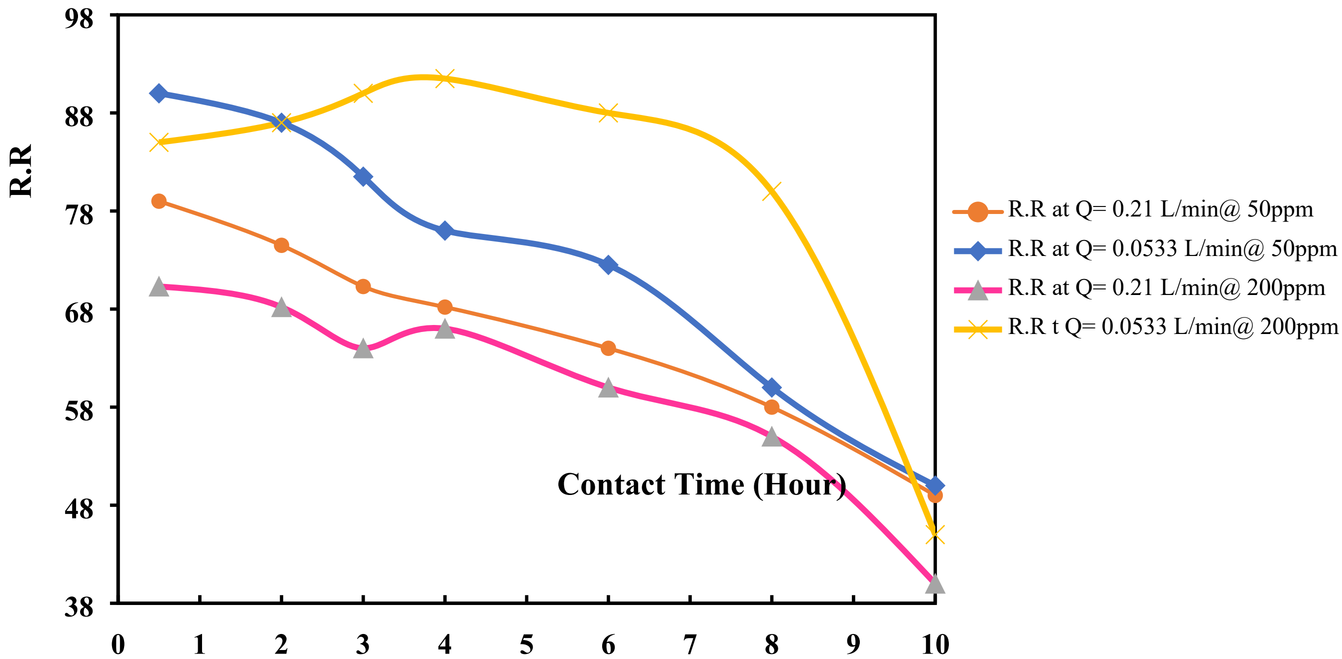


**Fig. S6**. Effect of Contact time (hour) on Removal ratio of dye at 0.21L/min, pH = 10, 15 cm height, initial conc 50 and 200 ppm

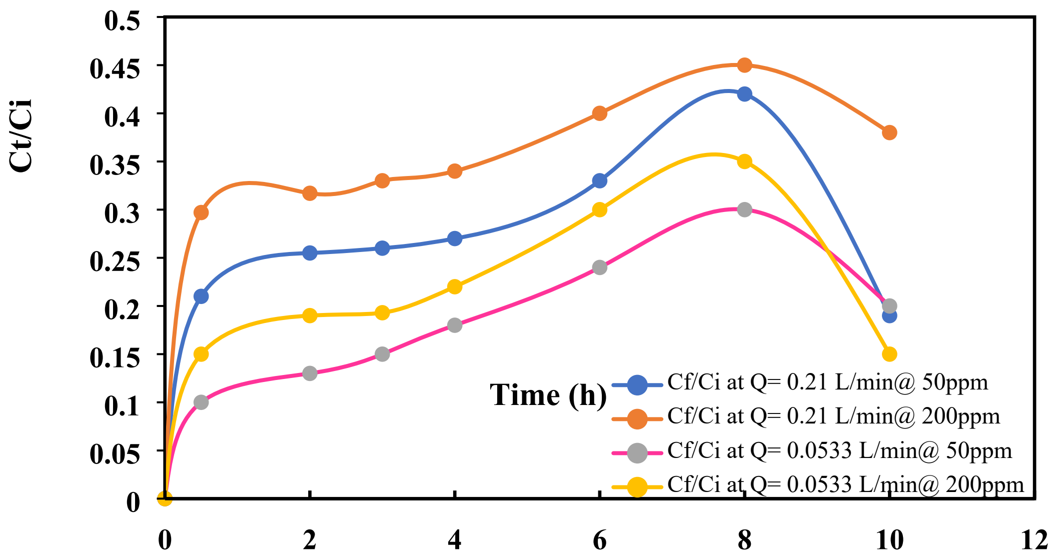


**Fig. S7**. Breakthrough curve

***Bohart–Adams model***

The basic mathematical correlation that relates $C_t/C_0$ and column operating time ($t$) for the purification of a flowing system was originally proposed by Bohart and Adam (Bohart & Adams, 1920) and can be presented as [30]

$$\ln\left(\frac{C_t}{C_0}\right) = K_{AB}C_0t - \left(K_{AB}N_0\left(\frac{Z}{F}\right)\right) \qquad \text{(eq.2.)}$$

Where $C_0$ and $C_t$ (ppm) are the inlet and effluent concentrations, $K_{AB}$ (L/mg min) is the adsorption rate constant, $F$ (cm/min) is the linear velocity determined by dividing the flow rate (mL/min) by the column sectional area (cm$^2$), $N_0$ (ppm) is the saturation concentration, $t$ is the flow time (min), and $Z$ (cm) is the adsorbent bed depth. The Adam–Bohart model was tested by plotting ln $C_t/C_0$ versus time (t) with a slope of $k_{AB}$ $C_0$ and an intercept of $k_{AB}N$ Z/F. $R^2$ validated the adsorption equation. According to the Adam-Bohart model, axial dispersion does not affect the dynamic adsorption process [30].

***Yoon-Nelson model***

Yoon and Nelson created a simple breakthrough behavior model. According to the model, the rate of decrease in the probability of adsorption for each adsorbate molecule is proportional to its adsorption probability and breakthrough on the adsorbent. The mathematical equation of Yoon– Nelson model can be written as: [30]

$ln\ (C_t\ /\ (C_0 – C_t)) = K_{YN}t - \tau K_{YN}$ (eq. 3.)

$$\ln\left(\frac{C_t}{C_0 - C_t}\right) = K_{YN}t - (\tau K_{YN})$$ [30]

Where $K_{YN}$ is the Yoon–Nelson velocity rate constant (1/min) and $\tau$ is the time (min) required for 50% of adsorbate breakthrough, a linear plot of *ln* ($C_t/C_0$-$C_t$) against the sampling time, t, was employed to determine the model parameters, $K_{YN}$ and$\tau$. $K_{YN}$ increases with bed flow rate, although Yoon-velocity Nelson's rate is constant. While the Yoon–Nelson model is comprehensive for analyzing adsorption columns, its validity is restricted to the conditions utilized [30].

***Thomson Model***

Another model used to assess adsorbent adsorptive capacity and predict breakthrough curves assumes second-order reversible reaction kinetics and the Langmuir isotherm. In theory, adsorption can be estimated with extremely low exterior and interior diffusion resistances.

The Thomas model is given by [3]

$$\ln\left(\frac{C_o}{C_t} - 1\right) = \frac{K_{th}q_F m}{Q} - K_{th}C_f t$$ (eq.4.)

Where kth, $q_0$, t is the Thomas model constant (mL/min mg), the equilibrium adsorbate uptake (mg/g), and total flow time (min), respectively. Accordingly, m and Q are the adsorbent dosage (g) and the flow rate (mL/min). $K_{th}$ and $q_0$ values were calculated from the linear representation of ln ($C_o/C_t$ – 1) against t. Using the Thomas model, this study described column breakthrough curves at various bed heights and flow rates [31]. With several couples of *m* and *Q*, $k_{Th,}$ and $q_F$ values derived through a plot of ln [($C_o/C_t$) −1] vs. *t*, further prediction and design are available. Eq. (65) can also be expressed as [29]

$$\ln\left(\frac{C_o}{C_t} - 1\right) = K^{'}(t - t_1)$$ (eq.5.)

As the solution runs across the column and the adsorption zone approaches the top, effluent concentration rises fast. This study set the breakthrough point at $C_t/C_o = 0.05$ and the exhaustion point ($C_t/C_o$ approached 1.0)when the effluent dye concentration neared the influent dye concentration [31].

Where $k'=k_{Th} C_o$ and $t_l= q_F m/ (QC_0)$. The general version of Eq. 6 is represented as [3]

$$\ln\left(\frac{C_o}{C_t}-1\right) = b_0 + b_1 t + b_2 t^2 + \ldots = \sum_i b_i t^i \qquad \text{(eq.6.)}$$

**Table S1**. Bohart–Adams model parameters for (MB on UV+ black sand) at different operation conditions on fixed bed column.

| Sand Depth (cm) | MB Conc. (ppm) | Q (mL/min) | $K_{AB}$ | $N_o$ | $R^2$ |
|---|---|---|---|---|---|
| 15 | 50 | 53.33 | 6.07E-05 | 2706.87 | 0.96 |
| | | 210 | 2.95E-05 | 14547.34 | 0.96 |
| | 200 | 53.33 | 4.53E-06 | 19396.26 | 0.94 |
| | | 210 | 4.51E-06 | 229751.50 | 0.94 |

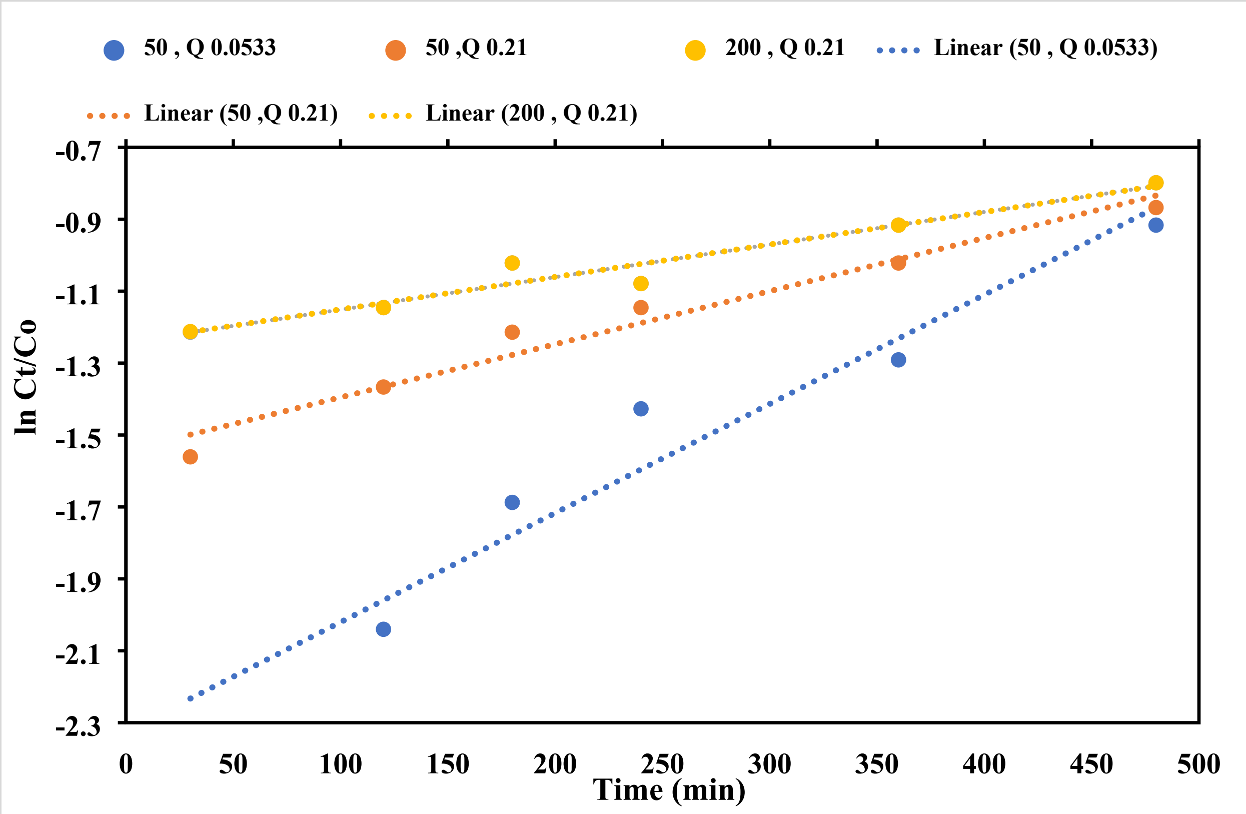


**Fig.S8.** Experimental data in Adam's Bohart model form (MB on UV+ black sand)

**Table S2**. Yoon–Nelson model parameters for (MB on UV+ black sand) at different operation conditions on fixed bed column.

| Sand Depth (cm) | MB Conc. (ppm) | Q (mL/min) | $K_{YN}$ | τ | $R^2$ |
|---|---|---|---|---|---|
| 15 | 50 | 53.33 | 0.0039 | 580.25 | 0.97 |
| | | 210 | 0.0011 | 1021.83 | 0.44 |
| | 200 | 53.33 | 0.0014 | 636.62 | 0.94 |
| | | 210 | 0.0014 | 637.36 | 0.94 |

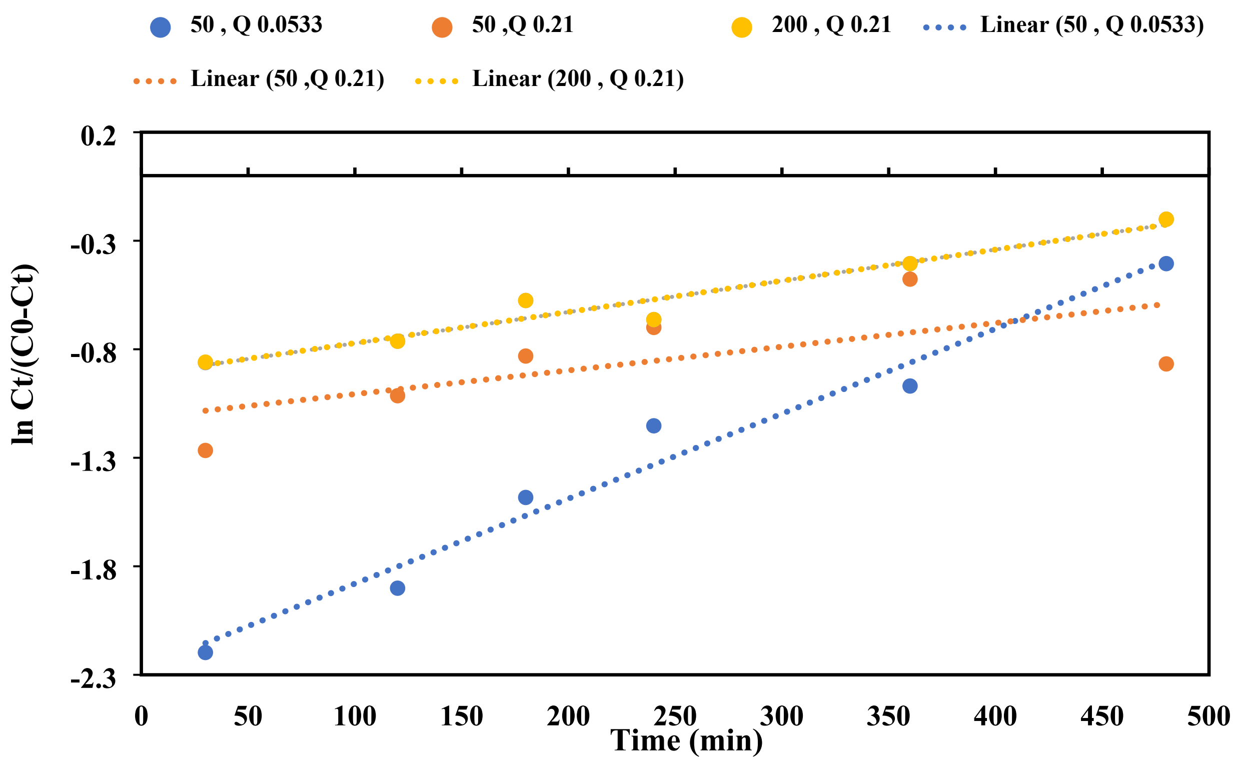


**Fig.S9**. Experimental data in Yoon Nelson model form (MB on UV+ black sand).

**Table S3**. Thomson model parameters for (MB on UV+ black sand) at different operation conditions on fixed bed column.

| Sand Depth (cm) | MB Conc. (ppm) | Q (mL/min) | $K_{th}$ | $q_F$ | $R^2$ |
|---|---|---|---|---|---|
| 15 | 50 | 53.33 | 7.82859E-05 | 562.319 | 0.97 |
| | | 210 | 4.29232E-05 | 2356.05 | 0.98 |
| | 200 | 53.33 | 7.19883E-06 | 2467.75 | 0.94 |
| | | 210 | 7.18051E-06 | 9734.26 | 0.94 |

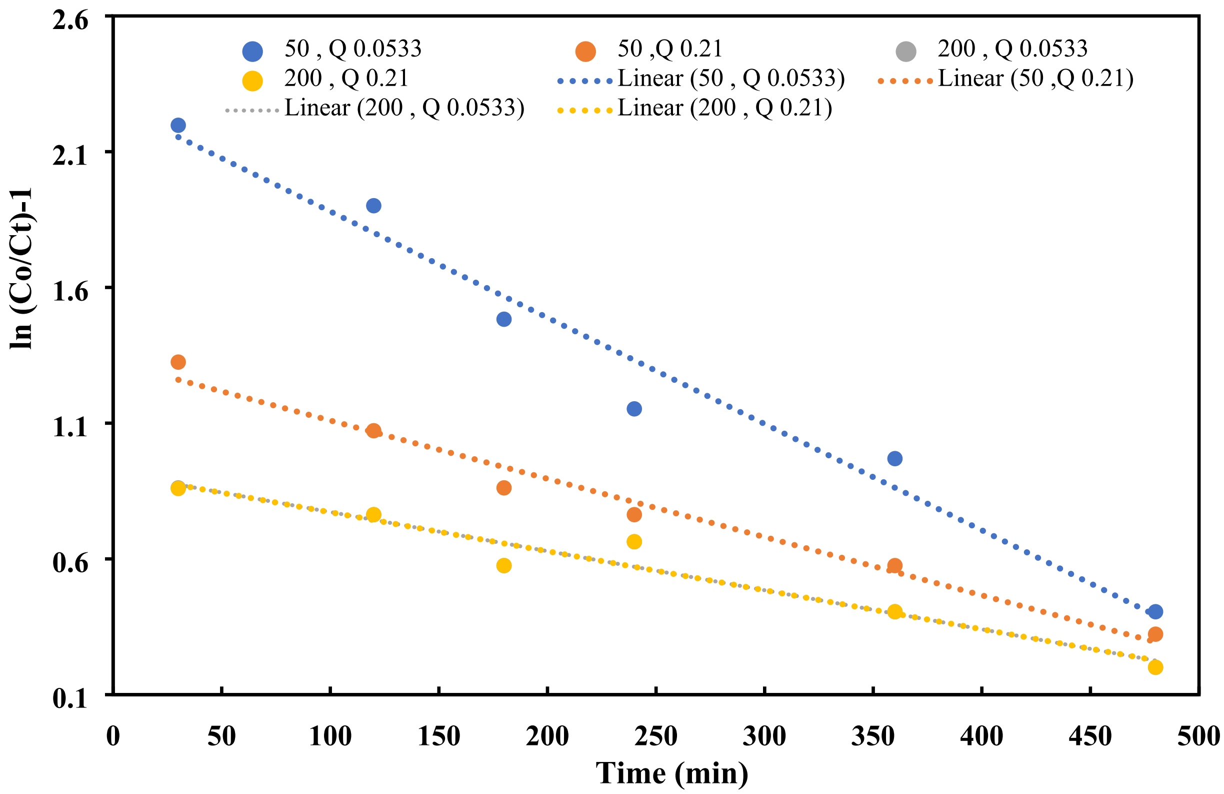


**Fig. S10**. Experimental data in Thomson model form

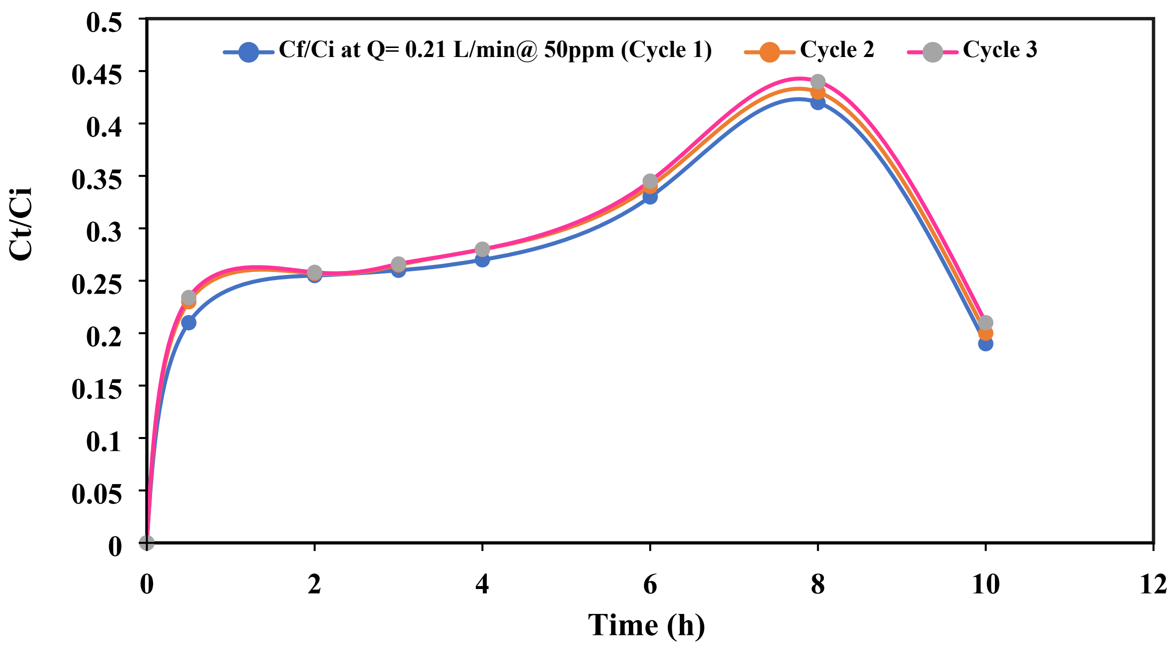


**Fig.S11**. Desorption curve for three cycles