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Optimizing Organic Contaminants Removal Using Rotating Biological Contactors – A Kinetic and Equilibrium Study

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ABSTRACT

This paper presents a study on optimizing organic contaminants removal using rotating biological contactors (RBCs) through a kinetic and equilibrium analysis. Response surface methodology was employed to explore non-linear relationships and identify optimal operating conditions for maximizing dodecane removal efficiency. Pseudomonas aeruginosa bacteria was chosen for the research due to its capacity to breakdown a wide range of hydrocarbons. The experimental data were analyzed using Design Expert software, and analysis of variance (ANOVA) was performed to assess the statistical significance of each variable and their interactions. The effects of beginning biomass content, initial dodecane concentration, and disc rotating speed were considered. The research provided insights into the relative importance of different factors and their combined effects on dodecane removal efficiency. The findings contribute to the understanding of microbial processes and the optimization of rotating biological contactor systems for efficient organic contaminant removal.

Keywords: dodecane, pseudomonas, response surface methodology, kinetic modelling, rotating biological contactors.

INTRODUCTION

The presence of organic contaminants in wastewater poses a significant threat to human health and the environment. These contaminants, originating from various sources such as domestic sewage, industrial effluents, and agricultural runoff, can cause a range of harmful effects, including eutrophication, waterborne diseases, and chemical toxicity [Chaturvedi et al. 2021]. To address these concerns, various methods have been developed to remove organic contaminants from wastewater. Physical methods, such as screening, sedimentation, and flotation, are effective in removing large solids and suspended organic matter [Miao et al. 2023]. Chemical methods, including chemical coagulation and chemical oxidation, are effective in removing a wide range of organic contaminants, including persistent organic pollutants [Bryukhov & Ulrikh, 2022]. Biological methods, such as the activated sludge process and trickling filters, utilize microorganisms to degrade organic matter in wastewater [Samer, 2015]. The choice of wastewater treatment method depends on the specific contaminants present, the desired level of treatment, and economic considerations. Each method has its own advantages and disadvantages, and a combination of methods may be used to achieve the desired treatment goals.

Each wastewater treatment method has its own set of disadvantages. Physical methods, such as screening, sedimentation, and flotation, can be energy-intensive and may not be effective in removing dissolved organic matter [Tran et al. 2015]. Chemical methods, such as chemical coagulation and chemical oxidation, can produce hazardous byproducts and may not be suitable for all types of organic contaminants [Miao et al. 2023]. Biological methods, such as the activated sludge process and trickling filters, require a constant supply of oxygen and can be sensitive to changes in temperature and pH [Harrison et al. 1984]. Rotating biological contactors (RBCs), also known as rotating biological filters or biodiscs, have emerged as a prominent technology in the realm of wastewater treatment and organic matter removal. Their efficacy, versatility, and adaptability have propelled them to the forefront of wastewater management strategies [Hassard et al. 2015].

Rotating biological contactors, also known as rotating biological filters or biodiscs, have established themselves as a valuable tool for wastewater treatment and organic matter removal. Their versatility, efficiency, and low maintenance requirements make them an attractive option for a wide range of applications [Hassard et al. 2015; von Rohr & Ruediger, 2001; Patwardhan, 2003]. As environmental concerns continue to grow, RBCs technology is poised to play an increasingly important role in protecting water resources and ensuring sustainable practices.

RBCs function on the principle of biological oxidation, where microorganisms attached to a rotating medium degrade organic pollutants in wastewater. These microorganisms form a biofilm on the surface of the discs, which are continuously rotated through the wastewater. As the discs rotate, they expose the biofilm to alternate cycles of aeration and wastewater immersion. This alternation facilitates the efficient removal of organic matter and nutrients such as nitrogen and phosphorus from the wastewater [Cortez et al. 2008]. RBCs have demonstrated their effectiveness in treating a wide range of wastewater streams, including municipal wastewater, industrial wastewater, and agricultural runoff. They are particularly well-suited for applications where space is limited or where energy efficiency is a priority [Hassard et al. 2015; von Rohr & Ruediger, 2001; Patwardhan, 2003; Cortez et al. 2008]. RBC technology offers several advantages over other wastewater treatment methods:

- high efficiency – RBCs achieve high levels of organic matter removal, typically exceeding 80%;
- compact design – RBC units occupy a relatively small footprint compared to other treatment systems;
- low energy requirements – RBCs operate with minimal energy consumption, making them an economical choice;
- resilience to shock loads: RBCs can withstand fluctuations in wastewater flow and organic load;
- low maintenance requirements: RBCs require minimal maintenance and operator attention.

In addition to their role in wastewater treatment, rotating biological contactors have garnered recognition for their efficacy in eliminating organic matter from diverse sources. Notably, RBCs demonstrate effectiveness in treating organic contaminants present in industrial waste streams emanating from processes in pulp and paper mills [Vergara-Fernández et al. 2007], textile mills [Vairavel & Murty, 2020], and food processing plants [Hendrasarie & Trilta, 2019]. Furthermore, these systems prove valuable in mitigating the impact of organic pollutants in agricultural runoff [Huang et al. 2022], thereby minimizing their adverse effects on receiving water bodies. RBCs also play a crucial role in treating landfill leachate [Tałałaj et al. 2019], preventing the release of organic contaminants into the environment. Additionally, their application extends to the remediation of contaminated sites, as RBCs contribute to the breakdown of organic pollutants in both soil and groundwater, showcasing their versatility in environmental stewardship [Mirbagheri et al. 2016].

The aim of this work is to investigate the interaction between hydrocarbon-degrading enzymes Pseudomonas aeruginosa cells and rotating biological contactors in the context of treating synthetic wastewater with dodecane as the sole carbon source. The study focuses on enhancing hydrocarbon removal efficiency by optimizing parameters such as beginning biomass content, initial dodecane concentration, and disc rotating speed (rpm). The research aims also to identify ideal conditions for maximum hydrocarbon removal utilizing response surface methodology to model and optimize the process. Response surface methodology (RSM) is a statistical and mathematical technique used to model and optimize complex processes. It involves the use of mathematical models to study the relationship between a set of input variables (factors) and the observed response of a system. The goal of RSM is to identify optimal conditions for a desired outcome by systematically varying the input variables [Khuri & Mukhopadhyay, 2010].

MATERIALS AND METHODS

Microorganisms

Pseudomonas aeruginosa bacteria ATCC 21034® was chosen to conduct this research because of its capacity to breakdown a wide range of hydrocarbons. The gram-positive bacteria *Pseudomonas aeruginosa* exhibits several distinct physiological characteristics, including the formation of yellow colonies on nutrient agar, motility, the production of spores, utilizing hydrocarbons as an energy source [Sivaprakasam et al. 2008]. *Pseudomonas aeruginosa* was chosen for this study due to its capacity to break down a wide range of hydrocarbons. The choice of this bacterium is likely based on its known ability to utilize hydrocarbons, including dodecane, as a carbon and energy source. *Pseudomonas aeruginosa* is known for its versatility in hydrocarbon degradation, making it a suitable candidate for the study focused on optimizing the removal of dodecane in wastewater using rotating biological contactors. Comparative advantages of using *Pseudomonas aeruginosa* over other bacteria in the degradation of hydrocarbons may include its adaptability to various hydrocarbon substrates, the production of hydrocarbon-degrading enzymes, and its resilience under different environmental conditions. The specific characteristics of *Pseudomonas aeruginosa* make it a valuable microorganism for the efficient breakdown of hydrocarbons, contributing to the success of the RBC system in removing dodecane from synthetic wastewater.

Culture medium

The aqueous phase was a mineral salt solution, whose composition is presented in Table 1. A bacterial strain was grown on a mineral medium with varying dodecane is a carbon and energy-rich compound in small levels (v/v).

Hydrocarbon

To facilitate the research process, dodecane ($C_{12}H_{26}$) was selected as the sole carbon source due to the inherent complexity of biodegrading hydrocarbon mixtures compared to pure hydrocarbons. Additionally, dodecane constitutes a significant portion of petroleum contaminants, accounting for approximately 42% of the total as displayed in Table 2 [Tjessem et al. 1984].

Table 1. Composition of culture media marmul

Compound	Quantity
$(NH_4)SO_4$	2 g
Na_2HPO_4	3.61 g
KH_2PO_4	1.75 g
$MgSO_4.7H_2O$	0.2 g
$CaCl_2$	50 mg
$FeSO_4.7H_2O$	1 mg
CuSO4.5H2O	50 mg
H_3BO_3	10 mg
$MnSO_4.7H_2O$	10 mg
$ZnSO_4.7H_2O$	70 mg
$(NH_4)6Mo_7O_{24}.4H_2O$	10 mg

Rotating biological contactor

The schematic illustration in Figure 1 depicts the RBC employed in this study. The laboratory-based RBC comprises four stages, each equipped with 50 parallel discs that rotate at varying speeds and are attached to a single shaft. Fabricated from acrylic plastic, the discs measure 40 cm in diameter and are submerged in the wastewater to approximately 40% of their surface area. Operated in batch mode, the RBC system maintains a temperature of 25 °C and a pH of 7.0. The RBC's specifications are detailed in Table 3

Experimental procedure

Tween-80, a surfactant, was employed to create a suspension of marmul$^+$ medium and dodecane as the hydrocarbon source [Tyagi et al. 1993]. Dodecane was incrementally introduced as drops into the combined marmul$^+$/surfactant solution, and the mixture was rapidly agitated for 2 hours to ensure uniformity. Subsequently, the prepared solution was supplied to the rotating biological contactors at room temperature, with the strain subjected to five distinct concentrations of dodecane: 50, 100,

Table 2. Mass percentage of alkanes in some petroleum products

No. of carbon atoms	10	11	12	13	14	15	16	17	18	19	20
% n-alkanes in Kerosene	6	39	42	13	Trace	-	-	-	-	-	-
% n-alkanes in gasoil	-	Trace	Trace	4	28	29	22	12	4	1	-
% n-alkanes in paraffins	-	-	1	2	3	5	8	14	21	19	13

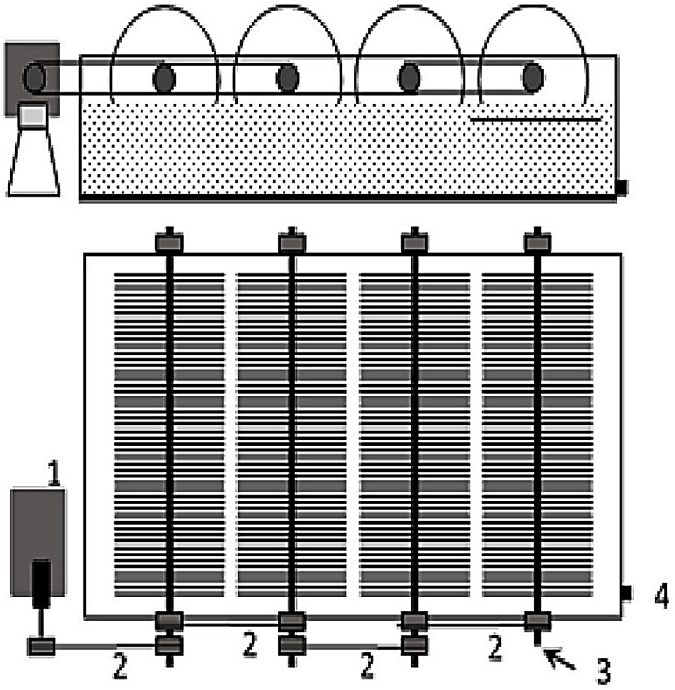

Fig. 1. Schematic diagram of RBC reactor: (1) drive motor; (2) belt conveyer; (3) shaft; (4) drain

Table 3. Specifications of RBC

Item	Specifications
Dimensions (L·W·D) m^3	(2·1·0.5)
Number of discs	50 · 4
Number of stages	4
Disc diameter (cm)	40
Disc thickness (mm)	3
Disc spacing (cm)	5
Rotational speed (rpm)	20
Working volume (m^3)	0.50
Submergence (%)	40
Temperature (°C)	25

200, 300, and 400 mg/L. To recover any remaining hydrocarbons in the bioreactor, hexane was utilized, and the extracted content was assessed using gas chromatography (GC-8A; Shimazu).

RESULTS AND DISCUSSION

Effect of initial concentration of hydrocarbon

Figure 2 shows the effect of initial concentration of hydrocarbon dodecane on the % removal, the data are divided into two regions from 50 to 200 mg/L and from 200 to 500 mg/L. As shown in Figure 2 when the initial concentration of HC increased from 50 to 200 mg/L, the % removal of organic contaminants increased from 18 to 66%. Further increase in the HC concentration beyond 200 up to 500 mg/L resulted in a decrease in the % removal to 57.4%. This phenomenon can be attributed to the enhanced biodegradation capacity of microorganisms when the hydrocarbon load is relatively low. At lower concentrations, the microorganisms have more readily available substrates, allowing them to metabolize the hydrocarbons efficiently. The decrease in % removal with increasing initial hydrocarbon concentration beyond 200 mg/L is likely due to a number of factors [Cortez et al. 2008]. First, the microorganisms may become overloaded at higher concentrations, leading to a decrease in their biodegradation capacity. Second, higher concentrations of hydrocarbons may produce inhibitory or toxic effects on the microorganisms. Finally, higher concentrations of hydrocarbons may lead to the formation of biofilms that are thicker and more difficult for the wastewater to penetrate, reducing the contact between the microorganisms and the hydrocarbons.

The relationship between initial hydrocarbon concentration and % removal is influenced by several factors [Cortez et al. 2008; Al-Ahmady, 2005; Rana et al. 2018; Najafpour et al. 2005]:

- Microbial activity: The biodegradation capacity of microorganisms is crucial in determining

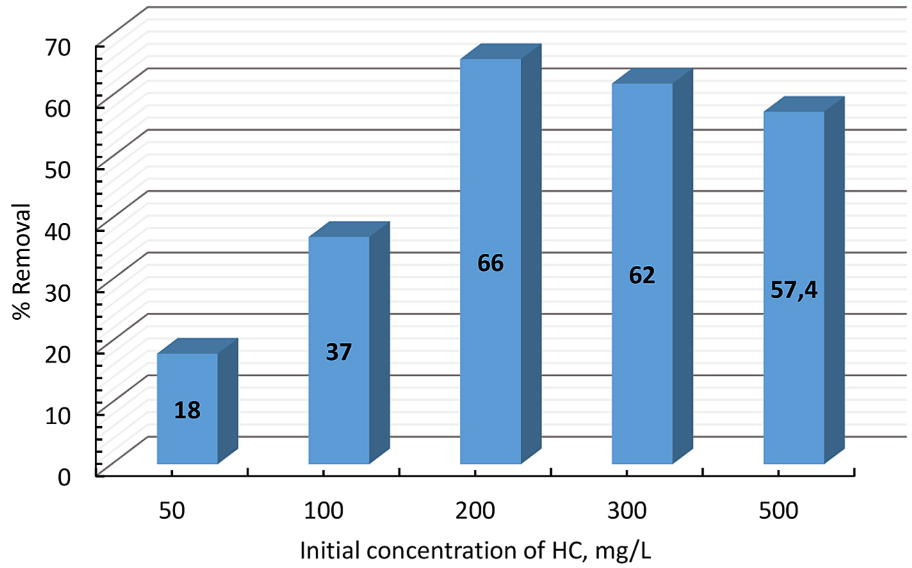

Fig. 2. Effect of initial concentration of HC on removal efficiency (disc rotation speed = 48 rpm; biomass dosage = 1000 mg/L; contact time = 84 min.)

the % removal of hydrocarbons. At higher initial concentrations, the microorganisms may become overwhelmed, reducing their biodegradation efficiency.

- Inhibitory or toxic effects: Elevated hydrocarbon concentrations can have inhibitory or toxic effects on microorganisms, hampering their ability to biodegrade the pollutants.
- Biofilm formation: Higher hydrocarbon concentrations may lead to the formation of thicker and denser biofilms, which can impede the diffusion of oxygen and wastewater into the biofilm, hindering the contact between microorganisms and hydrocarbons.

Several studies have investigated the effect of initial hydrocarbon concentration on % removal in RBCs. These studies consistently demonstrate a decline in % removal at high initial organic loading. For instance, [Al-Ahmady, 2005] investigated the effect of organic loading rate on RBC efficiency for wastewater treatment. The results showed that increasing organic loading rate from 0.5 to 2.5 kg/m^3/day resulted in a significant increase in RBC efficiency from 90% to 95%. However, when organic loading rate was increased further to 4 kg/m^3/day or more, RBC efficiency decreased due to excessive oxygen demand and substrate depletion. Rana et al. 2018 investigated the effectiveness of using a rotating biological contactor to remove organic pollutants, including phenolics. The removal efficiency was found to be dependent on the initial concentration of the organic pollutant, with higher removal efficiencies 56% being achieved at 250 mg/L initial concentration taking into account the other controlling factors.

Effect of biomass dosage

The dosage of biomass in a rotating biological reactor can significantly affect its removal efficiency. Previous works reported that the biocarrier filling rate, which is related to the biomass dosage, plays a crucial role in the performance of RBCs [Wang et al. 2022]. Additionally, the performance of RBCs in treating various pollutants, such as volatile organic compounds (VOCs) and carbonaceous BOD, is affected by the biomass dosage [Datta & Philip, 2014]. The removal efficiency of RBCs is a result of the metabolizing actions of bacteria and microorganisms present in the biomass [Wang et al. 2022]. Therefore, optimizing the biomass dosage is essential for maximizing the removal efficiency of RBCs. The dosage of biomass directly influences the biofilm development, nitrification, and the overall performance of the RBC system [Wang et al. 2022; Datta & Philip, 2014]. Hence, careful consideration of biomass dosage is crucial for achieving high removal efficiencies in rotating biological reactors. Figure 3 shows a plot of the removal efficiency versus the contact time at different biomass dosage. The figure shows that contact time

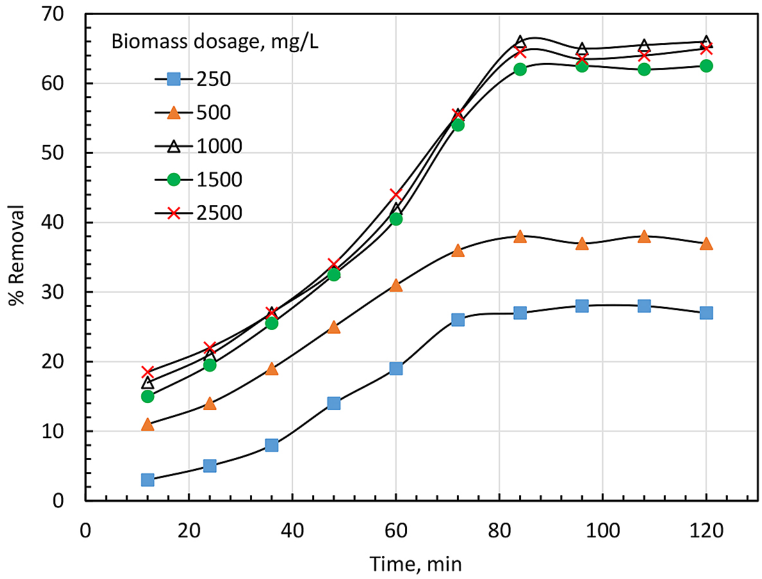

Fig. 3. Removal efficiency vs. time at different biomass dosages (initial concentration of HC = 200 mg/L, disc rotation speed = 48 rpm)

is an important factor in determining the removal efficiency of RBC reactors treating wastewater contaminated with dodecane. By increasing the contact time, it is possible to achieve higher removal efficiencies. However, it is important to note that there is a point of diminishing returns for contact time (96 min.), and further increases in contact time beyond this point may not be cost-effective.

Figure 4 shows the effect of biomass dosage on the removal efficiency of a rotating biological contactor treating wastewater contaminated with dodecane. The figure shows that the removal efficiency of dodecane increases with increasing biomass dosage. This is because a higher biomass dosage means that there are more microorganisms available to break down the phenol. The figure also shows that there is a point of diminishing returns. After a certain biomass dosage (1000 mg/L), increasing the biomass dosage further does not lead to a significant increase in removal efficiency. This is because the microorganisms are already able to break down the dodecane efficiently at this biomass dosage.The optimal biomass dosage for an RBC reactor will depend on a number of factors, including the type of wastewater being treated, the desired level of treatment, and the operating conditions of the reactor. However, the figure provides

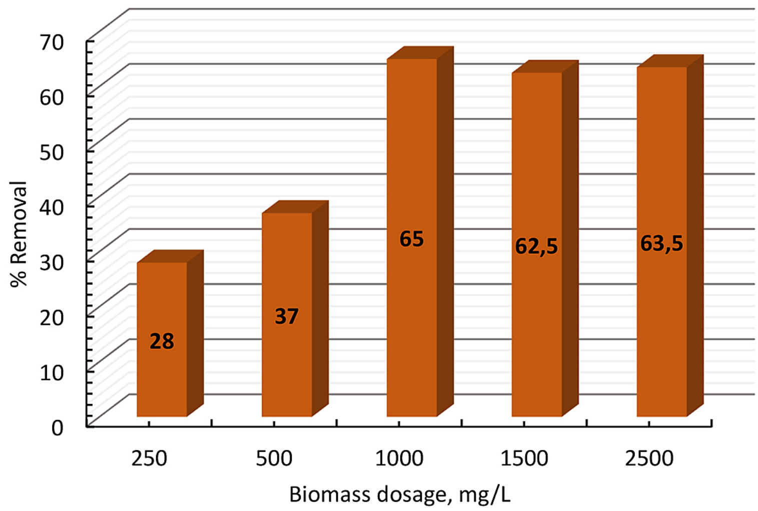

Fig. 4. Removal efficiency vs. biomass dosage (initial concentration of HC = 200 mg/L; disc rotation speed = 48 rpm; contact time = 96 min.)

a good general overview of the effect of biomass dosage on removal efficiency in an RBC reactor. The removal efficiency of dodecane increases significantly with increasing biomass dosage (e.g., from 28% to 65% between 250 mg/L and 1000 mg/L). There is a point of diminishing returns for biomass dosage (1000 mg/L), after which further increases in biomass dosage do not lead to significant increases in removal efficiency.

Effect of disc rotational speed

Figure 5 illustrates the impact of disc rotation speed on the removal efficiency of dodecane. The results reveal a notable enhancement in removal efficiency, rising from 28% at 12 rpm to 66% at 36 rpm. However, a subsequent increase in rotation speed to 48 rpm is correlated with a slight reduction in removal efficiency to 63%. Increasing the rotational speed of the disc introduces two conflicting impacts on removal efficiency, encompassing both positive and negative aspects. The positive outcomes attributed to the increase of disc rotation speed include the following [Cortez et al. 2008; Rana et al. 2018; Lu et al. 1997; Di Palma & Verdone, 2009; Waqas et al. 2023]:

- enhanced biofilm growth – higher disc rotation speeds promote the formation of a thicker and more active biofilm on the rotating discs. This increased surface area and microbial activity lead to improved substrate uptake and degradation, resulting in enhanced removal of organic contaminants;
- improved mass transfer – as the disc rotation speed increases, so does the mixing and turbulence in the wastewater. This enhanced mass transfer facilitates the movement of oxygen and organic matter to and from the biofilm, further boosting the biological treatment process;
- shear stress removal of excess biofilm – at moderate disc rotation speeds, the shear stress generated by the rotating discs helps to remove excess biofilm growth. This prevents the formation of excessively thick biofilms that can hinder substrate diffusion and reduce treatment effectiveness.

While the negative effects of excessive disc rotation speed are as follows [Cortez et al. 2008; Rana et al. 2018; Lu et al. 1997; Di Palma & Verdone, 2009; Waqas et al. 2023]**:**

- biofilm detachment and loss of biomass – excessive disc rotation speeds can generate excessive shear forces that lead to biofilm detachment from the discs. This loss of biomass can significantly reduce the treatment capacity of the RBC system;
- increased energy consumption – higher disc rotation speeds require more energy to operate the RBC system. This can lead to increased operational costs and environmental concerns;
- mechanical wear and tear – excessive disc rotation speeds can put undue stress on the rotating components of the RBC system, leading to accelerated wear and tear and potentially requiring more frequent maintenance.

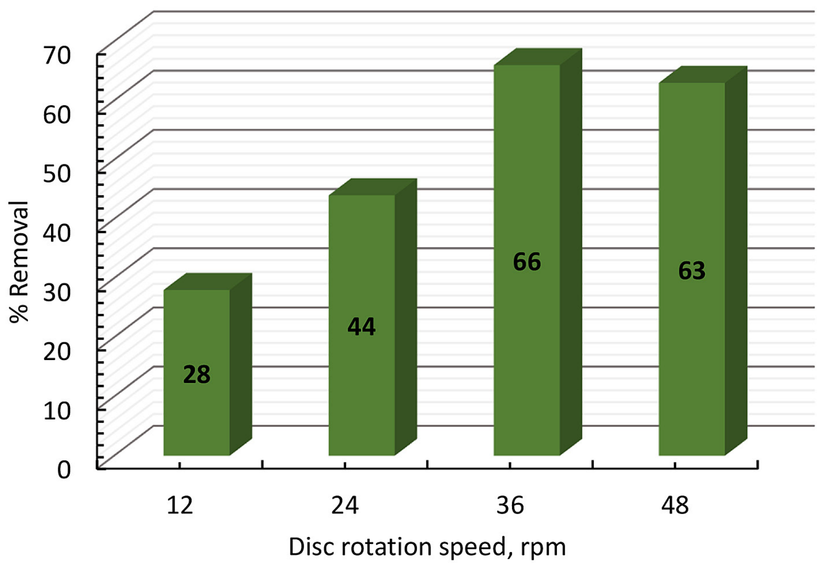

Fig. 5. Effect of disc rotation speed on the removal efficiency of dodecane

Within the range of parameters investigated, the positive impacts of increasing disc rotation speed appear to outweigh the negative effects up to 36 rpm. However, beyond 36 rpm, the decline in contaminant removal efficiency can likely be attributed to the detrimental effects of biofilm detachment and subsequent biomass loss. It is noteworthy to mention that the optimal disc rotation speed for a given RBC system depends on various factors, including the type and concentration of organic contaminants, hydraulic retention time (HRT), and desired treatment efficiency.

Response surface modeling and optimization for enhanced dodecane removal

In order to gain a deeper understanding of the complex interactions between the various factors influencing dodecane removal efficiency in the rotating biological reactor system, response surface methodology was employed. This statistical technique enabled the exploration of non-linear relationships and the identification of optimal operating conditions for maximizing dodecane removal. The experimental data was subsequently analyzed using Design Expert software, a powerful tool for RSM applications. ANOVA (analysis of variance) was performed to assess the statistical significance of each variable and their interactions. This rigorous statistical evaluation provided valuable insights into the relative importance of each factor and their combined effects on dodecane removal efficiency. The analysis of variance (ANOVA) results Table 4 summarizes the statistical significance of the independent variables (disc rotation speed, hydraulic retention time, influent dodecane concentration, and biomass dosage) and their interactions on dodecane removal efficiency. The table provides insights into the relative importance of each factor and their combined effects on the treatment performance of the rotating biological reactor system. The Model F-value of 69.81 implies the model is significant. P-values less than 0.05 indicate model terms are significant. Model reduction was applied for may improvement. In this case A, B, C, D, AB, A^2, B^2, C^2, D^2 are significant model terms. The data in Table 4 yield the following coded equation which correlates the controlling parameters to the % removal of dodecane.

$$\% \, Removal = 57.57 + 24.18\,A + 12.49\,B + 16.17\,C + 17.67\,D + 6.86\,AB - 7.93A^2 - 14.63\,B^2 - 14.29\,C^2 - 29.28D^2 \quad (1)$$

The above equation reveals that there is an interaction of the effect of contact time and the biomass dosage expressed as AB in the equation. Figure 6 shows the 3D surface plot of the interaction effect of both factors A and B and their corresponding contour plot (Fig. 7). In both figures the red area represent the conditions which achieve maximum removal efficiency, while the blue area represent the minimum. Figures 6 and 7 suggest that contact time and biomass dosage are two important factors that can be optimized to improve dodecane removal efficiency in RBC systems.

Table 4. ANOVA for reduced quadratic model

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	20499.04	9	2277.67	69.81	< 0.0001	significant
A-Time	12169.38	1	12169.38	372.96	< 0.0001	
B-Biomass dosage	3948.17	1	3948.17	121.00	< 0.0001	
C-Rotation speed	1010.44	1	1010.44	30.97	< 0.0001	
D-Initial concentration of HC	798.41	1	798.41	24.47	< 0.0001	
AB	486.93	1	486.93	14.92	0.0003	
A^2	462.33	1	462.33	14.17	0.0004	
B^2	1999.17	1	1999.17	61.27	< 0.0001	
C^2	211.18	1	211.18	6.47	0.0142	
D^2	1241.71	1	1241.71	38.06	< 0.0001	
Residual	1598.82	49	32.63			
Lack of fit	1592.82	47	33.89	11.30	0.0846	not significant
Pure error	6.00	2	3.00			
Cor total	22097.86	58				

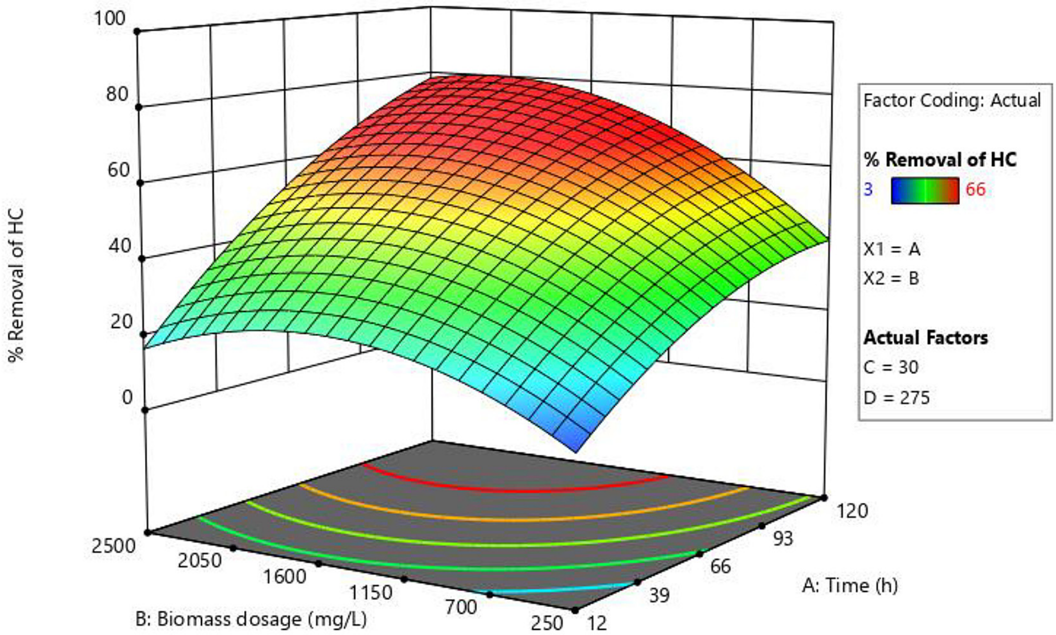

Fig. 6. 3D response plot of % removal of HC dodecane at different contact times and biomass dosages

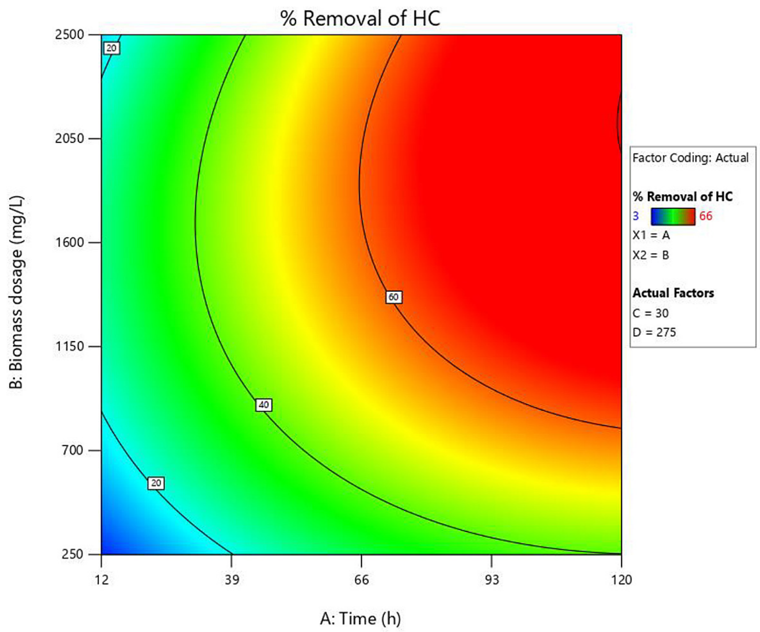

Fig. 7. Contour plot of % removal of HC dodecane at different contact times and biomass dosages

In order to verify the validity of Equation 1 in predicting the % removal of dodecane at different operating conditions, the predicted % removal was predicted against the actual % removal as shown in Figure 8. It shows that the model predictions generally match the experimental results well, with a few outliers. However, the overall agreement between the model predictions and the experimental results is good, which suggests that the model can be used to accurately predict dodecane removal efficiency in RBC systems under a variety of conditions. The model fit statistic is shown in Table 5. The predicted R^2 of 0.7224 is in reasonable agreement with the adjusted R^2 of 0.9144; i.e., the difference is less than 0.2. Adeq Precision measures the signal to noise ratio, the value 31.185 indicates an adequate signal where a ratio greater than 4 is desirable.

The model can be used to identify optimal operating conditions for maximizing dodecane

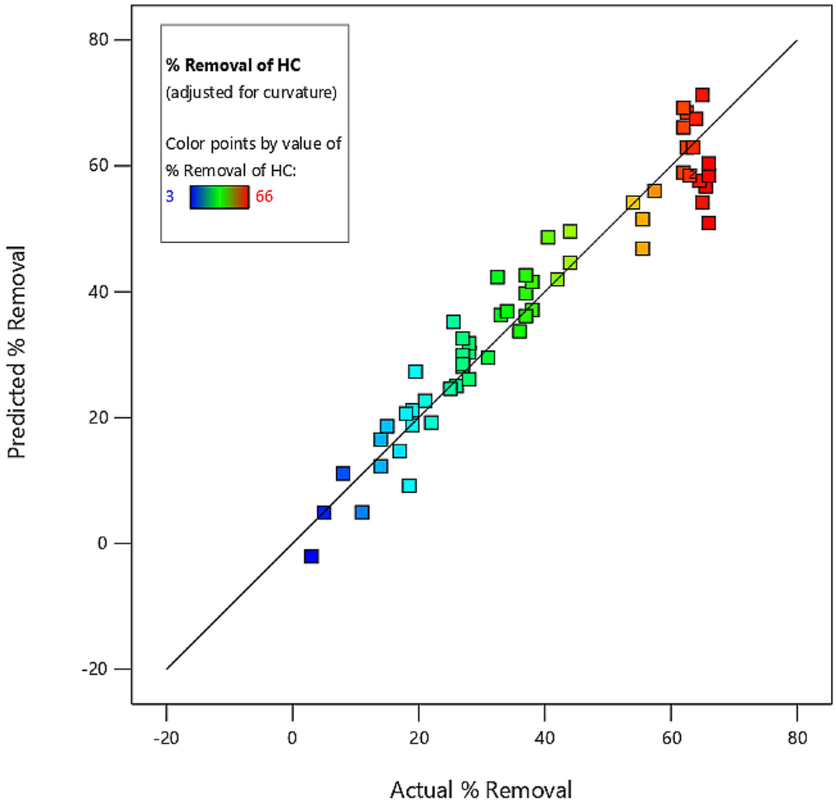

Fig. 8. Comparison of the experimental results and the obtained reduced quadratic model Equation 1

removal efficiency and to design RBC systems that meet specific performance goals. In order to optimize the removal process of dodecane by using rotating biological reactor equation (1) was solved by setting the goal to maximize the % removal. The optimizer function embedded within

Table 5. Fit statistics of the model

Std. Dev.	5.71	R^2	0.9276
Mean	38.38	Adjusted R^2	0.9144
C.V. %	14.88	Predicted R^2	0.7224
		Adeq precision	31.1853

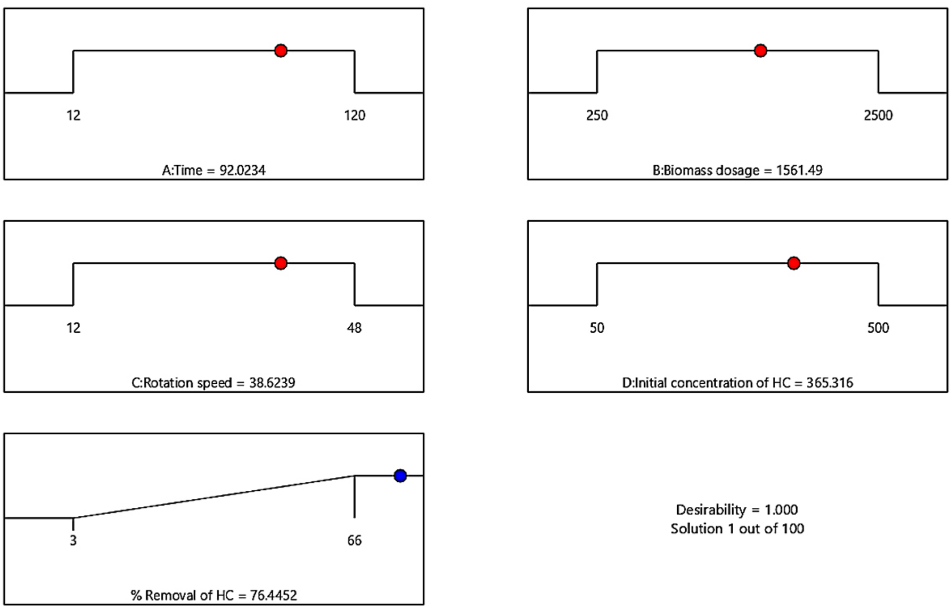

Fig. 9. Desirability ramp for optimization and optimum conditions for achieving maximum removal of dodecane

the RSM framework is employed to locate the maximum point on the response surface, corresponding to the ideal conditions for dodecane removal. This function operates iteratively, adjusting the input variables within their permissible ranges to identify the combination that produces the highest response. Consequently, the optimizer function's output reveals the optimal values of the controlling parameters that should be implemented to achieve the highest feasible efficiency in dodecane removal.

The desirability ramp in Figure 9 illustrates the optimal conditions for dodecane removal using a rotating biological contactor. These conditions include: contact time: 92 min; biomass dosage = 1561.5 mg/L; disc rotation speed = 38.6 rpm; initial dodecane concentration = 365.3 mg/L. Under these optimized conditions, the predicted dodecane removal efficiency reaches 76.44%. This optimized process can effectively remove a significant portion of dodecane from wastewater, improving overall treatment performance. It is important to note that the desirability ramp is a simplified representation of a complex system. In practice, there may be other factors that influence dodecane removal efficiency, such as the composition of the wastewater, the type of biomass, and the operating conditions of the RBC system. However, the desirability ramp is a useful tool for identifying the general trends and optimal conditions for maximizing dodecane removal efficiency.

CONCLUSION

The study demonstrated that rotating biological contactors can effectively remove organic contaminants from wastewater, including hydrocarbons like dodecane, through the formation of a biofilm on rotating discs. The initial hydrocarbon concentration, biomass dosage, and disc rotational speed have a significant impact on removal efficiency of dodecane in a rotating biological contactor system. The use of response surface methodology allowed for the optimization of operating conditions, such as disc rotation speed, hydraulic retention time, influent dodecane concentration, and biomass dosage, to maximize dodecane removal efficiency.

The research highlighted the importance of balancing disc rotation speed in RBC systems. Moderate rotation speeds help remove excess biofilm growth, while excessive speeds can lead to biofilm detachment and loss of biomass, reducing treatment capacity.

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