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DYNAMIC MODELING ANALYSIS OF OXYGEN TRANSFER MECHANISM AND WATER QUALITY DYNAMICS IN RECIRCULATING AQUACULTURE SYSTEMS

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ABSTRACT

Dissolved oxygen is an important indicator in intensive shrimp farming systems. This study aims to analyze the dynamics of oxygen transfer and identify water quality parameters that influence oxygen production levels in shrimp farming using the Recirculating Aquaculture System (RAS) with a dynamic system model approach. The study was conducted in six ponds in Pekalongan, Indonesia, during the RAS operational cycle. The water quality parameters observed were pH, temperature, dissolved oxygen (DO), and salinity, while oxygen transfer rates were analyzed using the standard oxygen transfer rate approach. Data analysis was carried out using statistical tests and dynamic system model analysis. The results showed that oxygen production levels in the RAS ponds ranged from 1.684 to 3.652 mg O_2/L/hour, with the highest value being 3.195 ± 0.15 mg O_2/L/hour (pond 2). Salinity had the strongest correlation with oxygen transfer rate ($r = 0.857$; $p < 0.01$), indicating its dominant influence on oxygen diffusion control through water viscosity and paddle aerator performance. PCA. Model simulation results indicated synchronization between paddle aerator rotation speed, water circulation hydrodynamics, and water quality, forming a positive feedback loop that increases the rate of oxygen diffusion in the pond. Conversely, reduced aeration leads to oxygen deficits and water quality fluctuations. Ecological engineering design, hydrodynamic optimization, and aeration management are fundamental factors in the operational cycle of RAS ponds.

How to Cite

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INTRODUCTION

Shrimp is a crucial commodity for supporting global food security. Global shrimp production reached 3,973.84 tons, with an annual production increase of 4% (FAO, 2026). Increasing global shrimp production requires the development of intensive farming systems using modern technology. In intensive shrimp farming systems, water quality is a determining factor in the success of aquaculture production (Ariadi et al., 2019; Huang et al., 2025; Sulthon et al., 2026; Widiasa et al., 2025). Stable water quality minimizes disease interventions and allows shrimp to grow optimally (Hukom et al., 2020; Janeo et al., 2009). Water quality, in addition to feed management, is a key factor in determining the success of shrimp farming (Madusari et al., 2022).

A crucial water quality parameter is dissolved oxygen. Dissolved oxygen in ponds directly affects shrimp respiration, aquatic metabolism, shrimp growth rate, and microorganism survival (Araujo et al., 2025; Jasmin et al., 2022; Miller and Rose, 2014). Dynamic fluctuations in dissolved oxygen can cause stress and mass shrimp mortality (Hiep et al., 2019; Rashdan et al., 2026). The ultimate impact is a simultaneous decrease in aquaculture productivity.

Intensive shrimp farming with high stocking densities carries a high risk of competition for oxygen, leading to a deficit. Furthermore, the presence of dense plankton in aquaculture ecosystems also impacts oxygen solubility through photosynthetic activity (Ariadi et al., 2022, 2024; Soeprapto et al., 2023). The presence of plankton in the operational cycle of aquaculture is highly paradoxical. During the day, they produce large amounts of oxygen, but at night, they cause oxygen depletion due to the absence of sunlight (C. Li et al., 2025; Y. Li et al., 2025). Increasing age and biomass of cultivated shrimp also impacts the level of dissolved oxygen consumption in ponds (Ariadi et al., 2025; Wafi et al., 2025).

The Recirculating Aquaculture System (RAS) is a shrimp cultivation technology developed to minimize the impact of water quality fluctuations and decreased dissolved oxygen. RAS is an aquaculture technology that utilizes mechanical and biological filtration systems for efficient water use and maintaining stable water quality (Canh et al., 2026; Halim et al., 2025; Hashmi et al., 2025; Hu et al., 2026; Uçar et al., 2026). Although RAS technology is highly preferred for maintaining pond water stability, the dynamics of oxygen consumption and production in this system remain highly complex. The oxygen budget in RAS technology is influenced by numerous operational and ecological factors (Montjourid and Susanna, 2025; Saengsuk et al., 2024; Taufik et al., 2024).

Published studies on RAS technology practices have largely focused on water filtration system preferences, waste management, and cultivar growth effectiveness. In RAS cultivation systems, the use of filtration technology can reduce organic waste pollution by 13–25% (Uçar et al., 2026). The amount of waste discharged with RAS technology is 50–300 kg/m^3 lower than with conventional cultivation technologies (Taufik et al., 2024). Other research indicates that the application of RAS technology can increase shrimp harvest productivity by 70–120 kg/m^3/cycle compared to conventional systems (Ahmed and Turchini, 2021). Consequently, studies on forecasting analysis of ecological performance in RAS ponds are still limited.

The novelty of this study is that the researchers attempted to identify the dominant factors controlling oxygen solubility levels in RAS shrimp ponds using a dynamic modeling system approach. The results are expected to provide scientific recommendations for the application of eco-engineering systems to optimize oxygen management in RAS farming. Based on this urgency, the objective of this study was to determine the level of dissolved oxygen production and the water quality factors that influence it in RAS shrimp ponds. The implications of this research align with Sustainable Development Goals (SDGs) 12 (Responsible Consumption and Production) and SDG 6 (Clean Water and Sanitation).

MATERIALS AND METHODS

Study area

This research was conducted at a six-pond study site in Slamaran Village, Pekalongan, Indonesia. All six ponds used RAS technology and shared similar treatments. Data were collected over one shrimp farming cycle (Figure 1).

Materials

The objects of this study were water samples and oxygen production data from RAS ponds, collected uniformly from six pond plots. Each water sample was observed in situ and ex situ based on actual field data. The water quality parameters measured in this study were pH, using a Lutron YK-2005WA, temperature and dissolved oxygen, using a YSI550i DO meter, and salinity, using an ATAGO PAL-06S hand refractometer.

Data analysis

Oxygen production rate

The oxygen production rate by the paddle aerator was estimated using the following formula (Abusam et al., 2001; Yeob et al., 2020):

$$OTR = SOTR \times \frac{(Cs - Cp)}{9.09} \times 1.024^{T-20} \times \alpha$$

$$SOTR = (KL\alpha) \times (Csat) \times (V) \times (10\text{-}3)$$

where OTR is the oxygen transfer rate (mgO_2/l/hour), 1.024^{T-20} is the temperature correction factor in pond water, SOTR is the standard oxygen transfer rate (mgO_2/l/hour), C_s is the pond salinity, C_p is the saturated oxygen in the pond, C_{sat} is the percentage of pond oxygen

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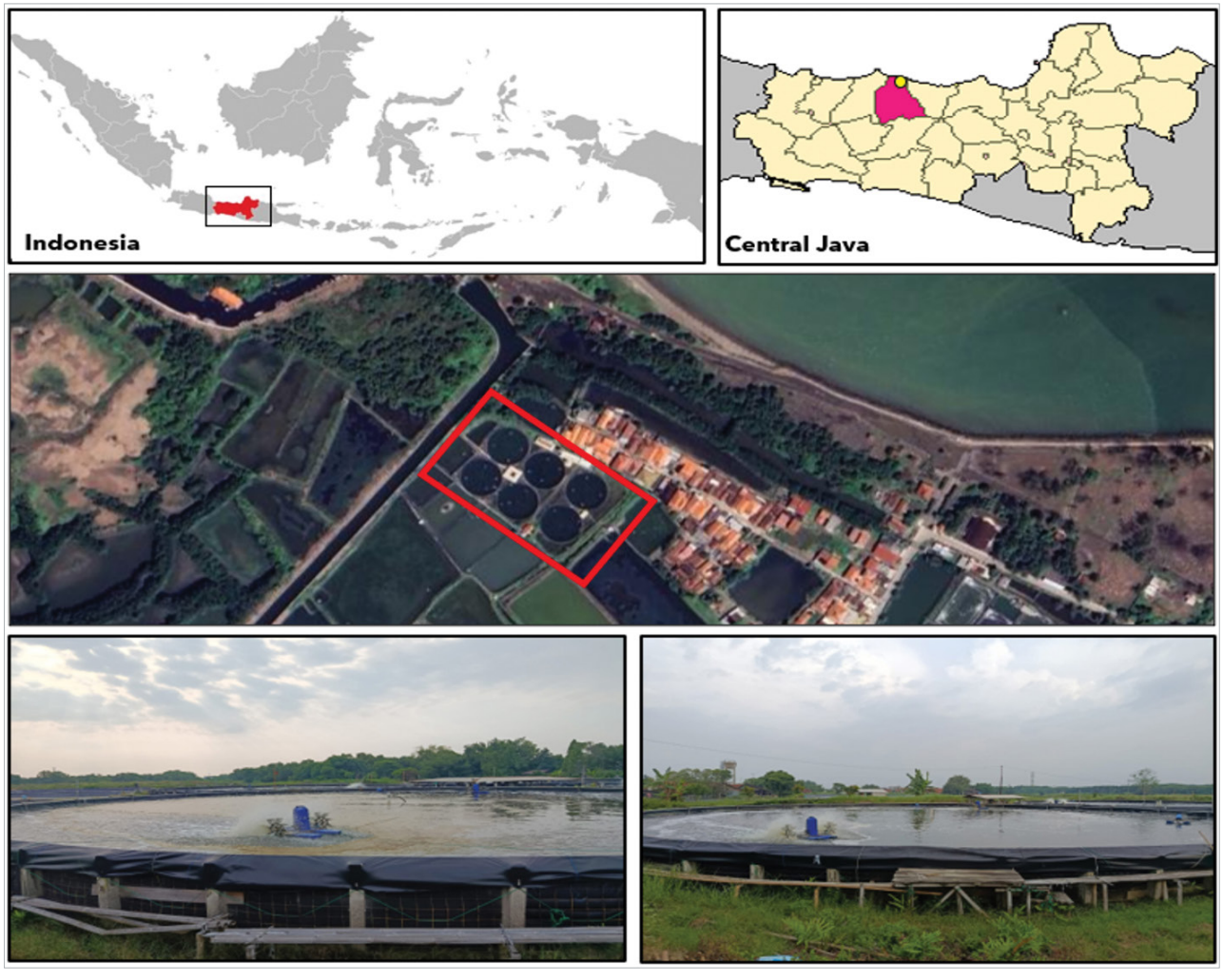


Fig 1. Research location area

saturation, $K_{L\alpha}$ is the atmospheric gas transfer coefficient (mg O_2/l/hour), α is the equilibrium coefficient (mg O_2/l/hour), V is the pond water volume (m^3), and 9.09 is the oxygen diffusion deviation value.

Statistical analysis

The data analysis in this study utilized several analytical techniques. To determine the correlation between parameters, a correlation test was conducted in IBM SPSS ver. 25. The level of the relationship between oxygen transfer and water quality parameters was analyzed using Principal Component Analysis (PCA) and cluster analysis with PAST software ver. 4.0, and Stella software ver. 9.02 was used for system dynamic model analysis.

RESULTS AND DISCUSSION

Recirculating Aquaculture System (RAS) in pond design

The RAS in pond design uses a cylindrical tank configuration to improve pond water circulation efficiency, water quality stability, and effective space utilization by farmers. This system integrates effective pond aeration, drainage placement, and controlled water inflow and outflow to support shrimp growth in intensive farming practices (Ahmed and Turchini, 2021; Yang et al., 2024). The RAS pond has a diameter of 16–20 m, a wall height of 1.2–1.5 m, and a depth of 1.0–1.2 m. This means that for a typical shrimp farming cycle, an optimum volume of approximately 110–380 m^3 is achieved. The RAS pond wall structure uses a mixture of concrete and HDPE liner to strengthen the pond's resistance to hydrostatic pressure, prevent leaks, and facilitate post-harvest maintenance. The RAS pond has a bottom slope of approximately 1–2%, which facilitates effective collection of cultured sludge due to the pond's reduced gravity (Figure 2). The pond is designed in a simple form, with a moderate height to facilitate shrimp feeding operations, siphoning, and water quality treatment during the shrimp farming operational cycle (Huysman et al., 2025).

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Fig 2. RAS pond conditions in research area

The hydrodynamic concept of this system was developed using a circular flow pattern with the aid of four symmetrically positioned paddle wheel aerators. The symmetrical placement of the aerators generates a horizontal thrust, creating an intense current rotation to maintain temperature homogeneity and oxygen solubility (El-Rewiny et al., 2026; Wang et al., 2025; Zhang et al., 2025). Furthermore, the circular flow facilitates even feed distribution and makes the removal of waste and suspended particles from the pond ecosystem more efficient (Zhu et al., 2026). The drainage system is designed at a central point in the pond, connected to a water circulation channel. This concept aligns with the theory of fluid flow configurations in which flow proceeds continuously from high-pressure points to low-pressure points (Ayuso-Virgili et al., 2023; Cheng et al., 2020). The drainage system is also linked to the hydrodynamic model of water management in the pond ecosystem to be developed.

The water management system configuration in this RAS pond is also designed to prevent the formation of dead zones that trigger oxygen depletion in the pond (Jayanthi et al., 2021; Jayraj et al., 2025). Therefore, fluctuations in oxygen solubility and increases in suspended waste can be biologically suppressed. Some technical advantages of using circular ponds in RAS cultivation include easier environmental control, efficient use of land and water resources, biosecurity practices, and increased cultivation productivity (Ayuso-Virgili et al., 2023). Several studies also state that circular ponds are more effective for energy and current distribution than rectangular ponds because they have no corners where sediment accumulates on each side of the pond (Zhu et al., 2026). Through the application of hydrodynamic theory and good cultivation management, RAS is very suitable for intensive and super-intensive shrimp farming (Figure 3).

Pond water quality

Water quality parameters at the research pond sites are relatively dynamic. The pH of pond 1 tends to be higher than in the other ponds (Table 1). Other water quality parameters tend to be more uniform and still meet water quality standards. Water quality conditions that meet quality standards support shrimp growth and minimize physiological stress. Water quality parameters in the pond ecosystem fluctuate dynamically throughout the cultivation period.

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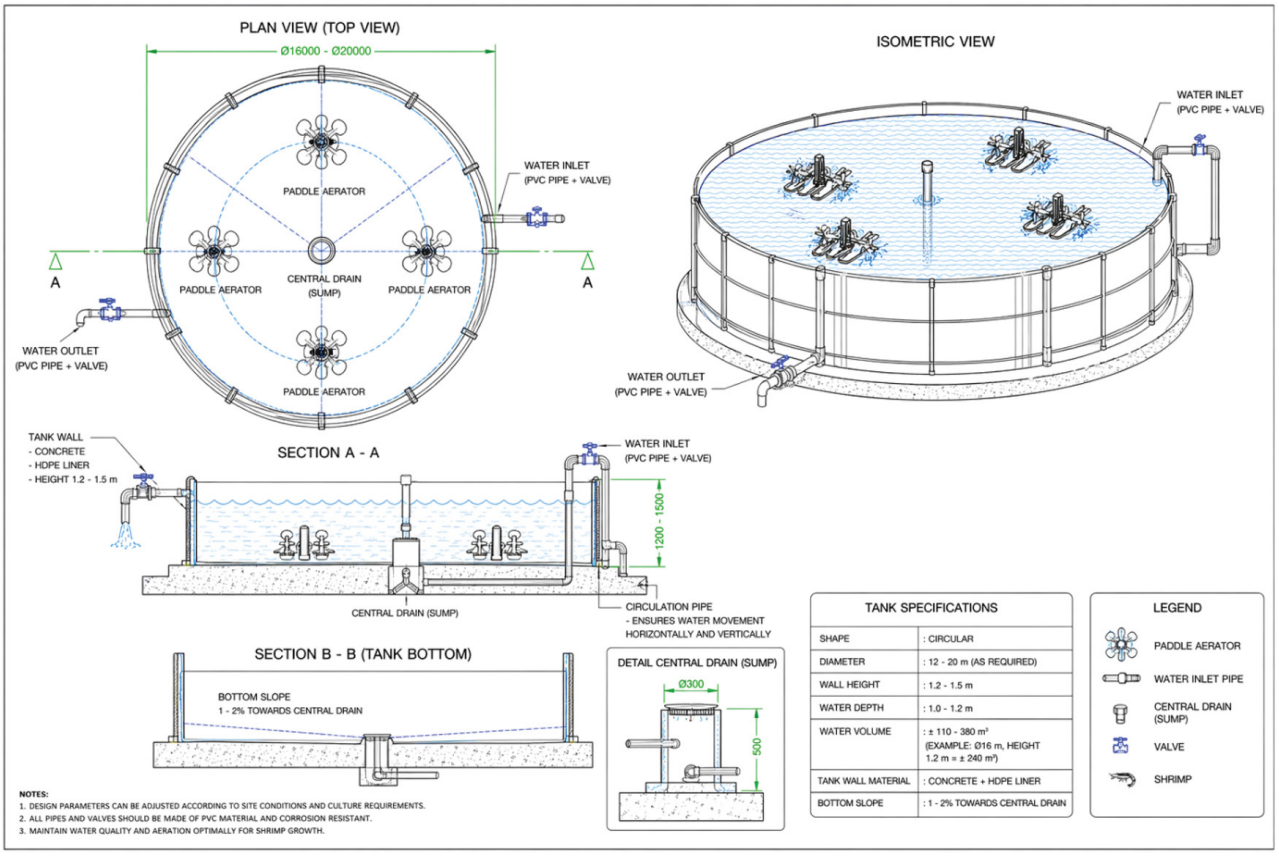


Fig 3. Layout design of Recirculating Aquaculture System

Table 1. Water quality profile of RAS in shrimp farming

Parameters	Pond			
	1	2	3	4
pH water	8.1 – 9.2 (8.6 ± 0.30)	7.7 – 8.9 (8.1 ± 0.33)	8.0 – 9.1 (8.5 ± 0.30)	7.8 – 8.9 (8.3 ± 0.30)
Temperature (˚C)	28.8 – 32.0 (30.3 ± 0.96)	26.5 – 29.7 (28.0 ± 0.96)	27.6 – 33.1 (30.3 ± 1.46)	23.9 – 29.4 (26.6 ± 1.46)
Dissolved oxygen (mg/l)	3.53 – 5.83 (4.25 ± 0.54)	4.42 – 6.72 (5.14 ± 0.54)	4.03 – 6.33 (4.75 ± 0.54)	4.70 – 8.31 (6.55 ± 0.80)
Salinity (gr/l)	20 – 27 (22.9 ± 2.23)	20 – 27 (23.1 ± 2.13)	20 – 27 (23.1 ± 2.13)	20 – 27 (23.1 ± 2.13)

Water quality data show a trend correlation between temperature and dissolved oxygen, with pond 4 having the lowest temperature and the highest oxygen solubility. This means that oxygen solubility in the pond ecosystem is significantly influenced by water temperature. Temperature affects atmospheric pressure and oxygen diffusion in the pond ecosystem (Ariadi et al., 2021; Ariadi and Mujtahidah, 2023). The salinity levels of the four ponds were identical because they source their water from the same location. Stable salinity significantly affects the shrimp osmoregulation system, which is significantly improved. Aquaculture pond water quality tends to fluctuate depending on ecological and seasonal conditions (Uka et al., 2026). Water quality can be stabilized if intensive, consistent treatment is applied throughout the aquaculture operation (Mazuran and Kovacevic, 2025).

Dissolved oxygen production rate

The highest oxygen production was found in pond 2, with a solubility of 3,195 ± 0.15 mgO_2/L/hour, and the lowest in pond 1, with a solubility of 2,121 ± 0.31 mgO_2/L/hour (Figure 4).

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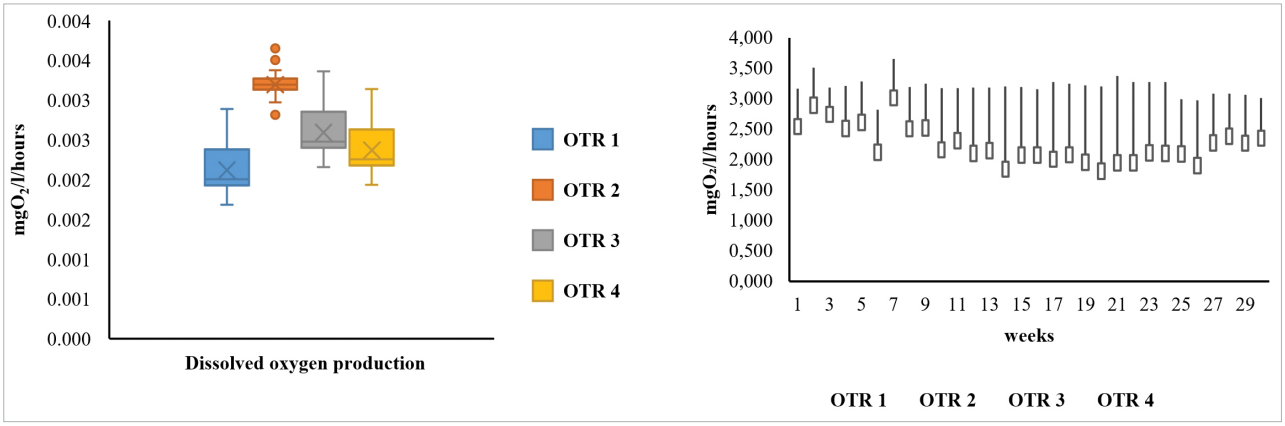


Fig 4. Dissolved oxygen production level in RAS ponds

Oxygen production levels in the RAS ponds ranged from 1,684 to 3,652 mgO_2/L/hour. This means that in one hour, the RAS pond can produce an average of 2,570 mgO_2/L of oxygen. This value was achieved using a pond area of 23.55 m^3 and a 6 HP paddle aerator. Pond water volume and environmental factors are key indicators determining the level of oxygen solubility in the pond ecosystem.

The varying levels of oxygen production in each RAS pond are influenced by the growth rate of shrimp biomass. Shrimp biomass growth impacts the cumulative oxygen consumption rate and the need for high organic waste absorption. The fluctuating dynamics of oxygen transfer rates are also influenced by salinity levels and wind speed, which are limiting factors for oxygen diffusion (Xiong et al., 2025). Oxygen in pond ecosystems diffuses from higher to lower pressure without passing through a semi-permeable membrane (Maharani et al., 2024; Yu et al., 2026). This theory applies directly to the principle of using paddle aerators in RAS ponds.

Water quality parameters correlation

The results of the Pearson correlation analysis are shown in Table 2, which shows that oxygen production in RAS ponds is significantly correlated with water pH and salinity. This means that salinity stability and pH dynamics in pond water continuously influence the effectiveness of oxygen solubility in the pond. The pH in the Pearson correlation analysis is closely related to the solubility level, temperature, and salinity. Meanwhile, salinity correlates significantly with all water quality parameters (pH, dissolved oxygen, and salinity).

The water quality in RAS pond ecosystems is highly dynamic, significantly influencing all water quality parameters. Salinity is a determining factor in the rate of oxygen transfer in ponds because it is related to water viscosity. Viscosity affects the rotational speed of paddle aerator propellers at their torsion angle, thus impacting the size of the water droplets produced (Hiep et al., 2019; Maharani et al., 2024; Ramesh et al., 2024). The intensity of these water droplets impacts the rate of oxygen diffusion. This concept is crucial for implementing RAS cultivation models, which rely on stable oxygen production in the pond ecosystem.

The results of the PCA cluster test indicate that in quadrant 1 (component 1), oxygen production in RAS ponds is influenced by salinity levels, temperature distribution, and pH (Figure 5). Salinity and temperature are limiting factors in the process of oxygen diffusion in pond water (Jasmin et al., 2022). The DO value in quadrant 2 indicates that the level of oxygen solubility in RAS pond water does not have a significant correlation with the level of oxygen production in the pond water ecosystem.

Table 2. Results of correlation tests between pond water quality parameters

Parameter	Oxygen transfer rate	pH	Temperature	Dissolved oxygen	Salinity
Oxygen Transfer Rate	1	0.389*	0.250	0.238	0.857**
pH	0.389*	1	0.498**	0.411*	0.626**
Temperature	0.250	0.498**	1	0.282	0.488**
Dissolved Oxygen	0.238	0.411*	0.282	1	0.454*
Salinity	0.857**	0.626**	0.488**	0.454*	1

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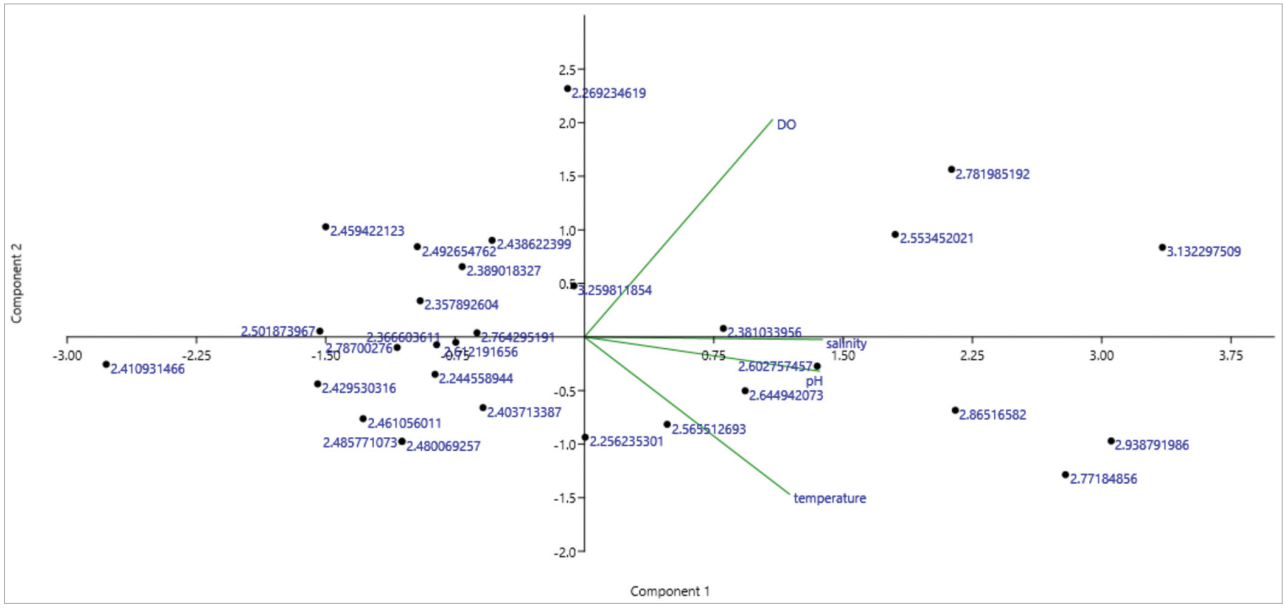


Fig 5. PCA cluster results with biplot analysis

A key finding from the above analysis is that the primary water quality parameter that significantly influences oxygen production levels in RAS ponds is salinity. Salinity is related to water viscosity, which affects the rotation rate of the paddle aerator in producing oxygen (Ariadi and Mujtahidah, 2023). Furthermore, the co-impact between salinity, solubility and liquid viscosity determines the amount of liquid pressure in the pond water, which in turn influences the oxygen diffusion process (Sun et al., 2026). The difference between water pressure in the pond and atmospheric air determines the oxygen transfer process by diffusion.

The analysis also showed that the DO parameter had the longest vector (Figure 5). This confirms that in the RAS pond ecosystem, dissolved oxygen is the primary factor influencing water dynamics. The scientific interpretation is that fluctuations in dissolved oxygen are followed by temperature and salinity, causing dynamic fluctuations in water quality. This condition naturally occurs due to the diurnal cycle (Blazhekovikj–Dimovska, 2024; Ariadi et al., 2023). In a controlled pond system, the effects of fluctuations in several water quality parameters can be suppressed and used as an environmental engineering model to enable the cultivation of plants (Ariadi et al., 2025).

Dynamic model analysis

A description of the causal loop model in the dynamic system model analysis is presented in Figure 6. The correlation parameters formed in the dynamic system model refer to related theoretical studies. The level of oxygen production by the paddle aerator in the RAS pond, along with wind speed and pond water current flow, directly influence dissolved oxygen levels and water quality conditions. Good water quality conditions, indicated by stable oxygen levels, reduces the potential waste generation caused by the accumulation of feed waste and an increase in the burden of cultivated biomass accumulated in the waste load in the pond (Ariadi et al., 2024, 2025; Song et al., 2026). The high abundance of waste load in RAS ponds can be managed by using sufficient paddle aerators and a stable flow rate, thereby reducing the degradation rate caused by cultivation waste (Figure 6).

Based on the causal loop model formulation above, a graphical data pattern is generated through forecasting, as presented in Figure 7. The results of the dynamic model simulation illustrate an interactive relationship between water quality, rotation rate, and oxygen transfer rate in RAS ponds. This multivariable relationship was found to differ in each RAS pond studied. In general, the model analysis indicates that each pond exhibits different system response dynamics to rotation rate and oxygen transfer rate. This means that water hydrodynamics and the effectiveness of paddle aerator placement as a source of aeration are important factors in maintaining the balance of the RAS pond ecosystem.

Pond A illustrates that an increase in rotation rate is followed by an exponential increase in oxygen transfer rate until it reaches a near steady state, accompanied by a progressive improvement in water quality (Figure 7). This positive feedback loop phenomenon indicates that water circulation speed can increase turbulence and contact between water and air, thereby increasing oxygen diffusion efficiency (Roy et al., 2024). Pond B shows a linear and balanced trend of increasing variables, indicating that the system remains at optimum conditions, with aeration capacity proportional to oxygen demand in the environment (Figure 7). The performance of this model demonstrates that a stable rotation rate creates a pond environment that is resilient to fluctuations in water quality.

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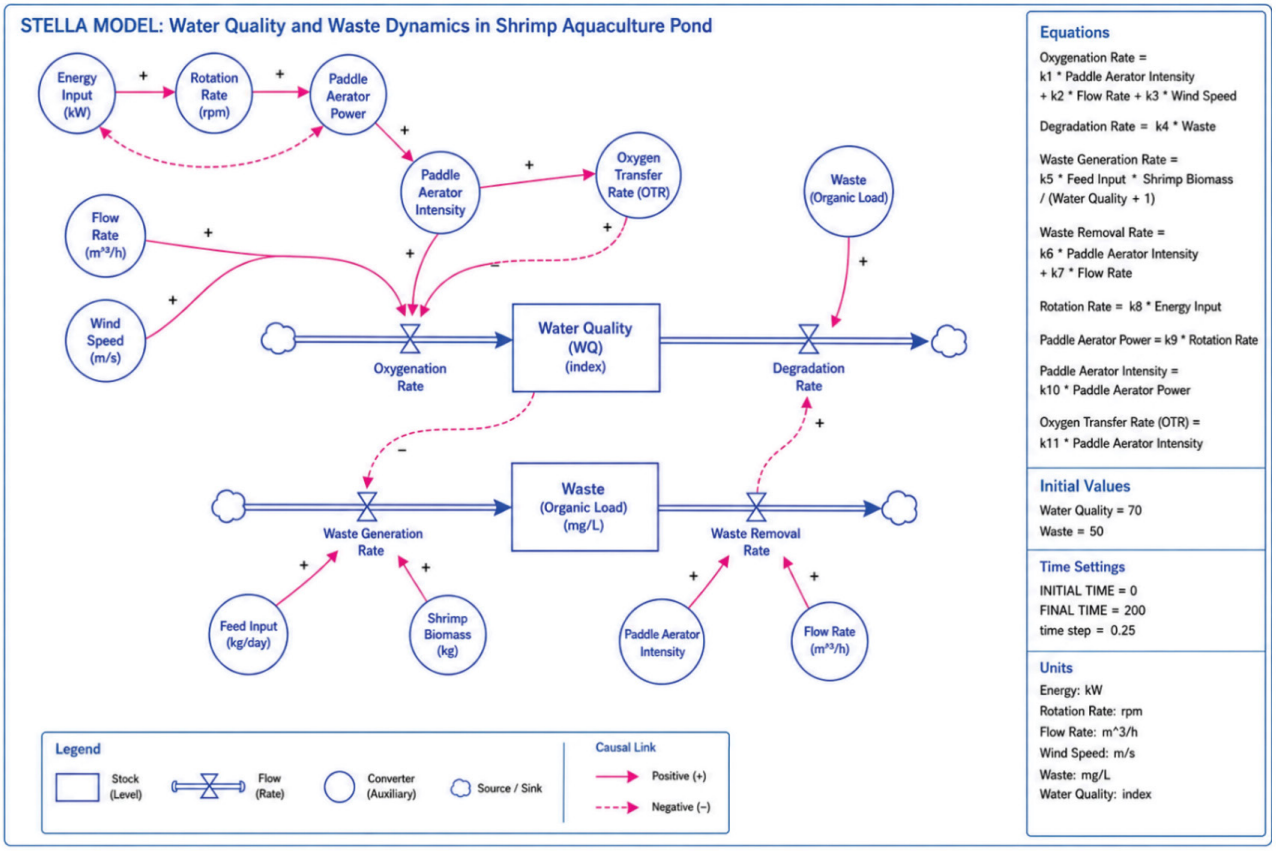


Fig 6. Causal loop model of oxygenation rate and water quality in RAS ponds

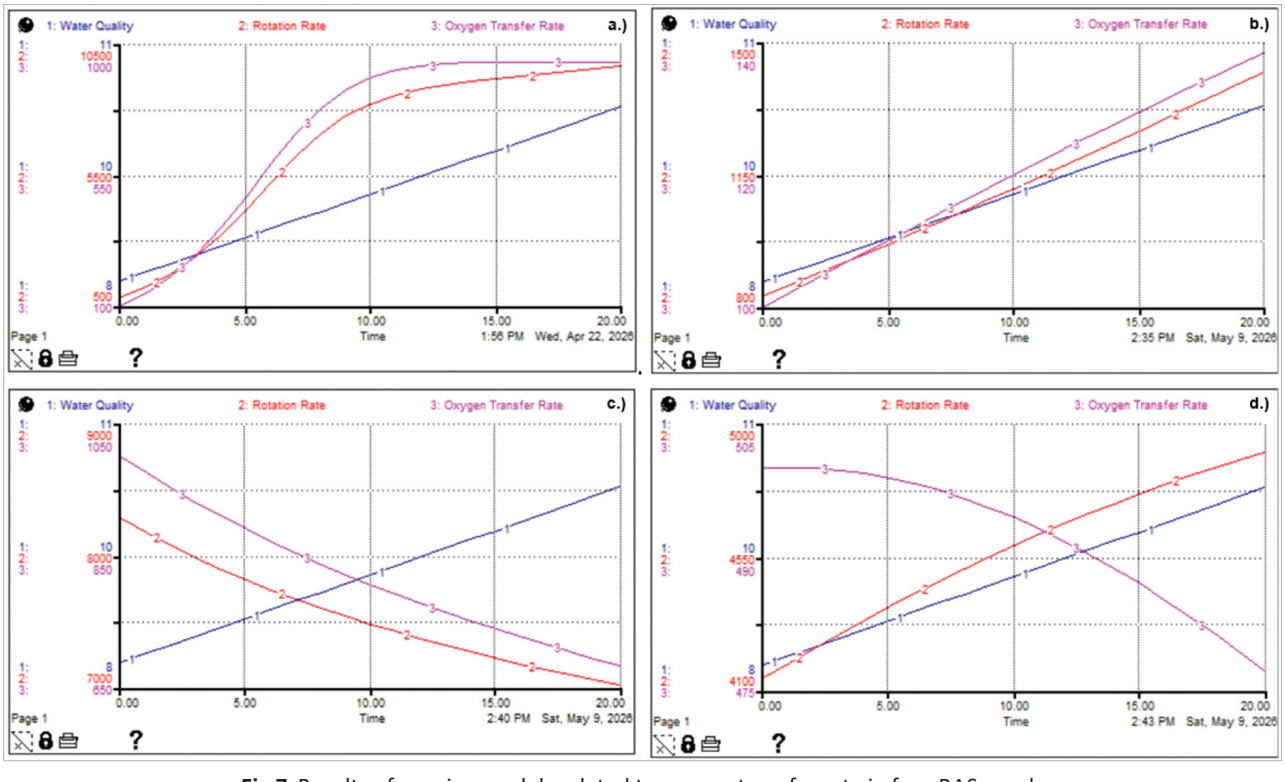


Fig 7. Results of running models related to oxygen transfer rate in four RAS ponds

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Pond C demonstrates a decrease in rotation rate and oxygen transfer rate, followed by degradation of pond water quality (Figure 7). This negative ecological response model demonstrates that decreased oxygen transfer in the water results in increased waste and decreased waste assimilation capacity. Pond D demonstrates an antagonistic relationship between rotation rate and oxygen transfer rate (Figure 7). Overall, the results of this balancing feedback loop model explain the limitations in environmental performance when system factors begin to reach their operational optimum. The model simulation results indicate that the success of RAS cultivation is significantly influenced by the synchronization of oxygen transfer rates and pond water circulation performance. Therefore, the application of hydrodynamic concepts, the regulation of paddle aerator requirements, and the efficiency of water flow circulation have a fundamental impact on the sustainability of the shrimp cultivation cycle in RAS ponds.

The cylindrical design of RAS ponds significantly impacts the effectiveness of water hydrodynamics, pond water quality, and oxygen transfer rates in shrimp farming (Cheng et al., 2020; Moghbeli et al., 2023; Zhu et al., 2026). The circular flow pattern of RAS ponds, with symmetrical paddle aerator placement and a central drain system, creates homogeneous water circulation and minimizes dead zones. This is justified by the good water quality of the RAS ponds, which meet quality standards. This pond design significantly impacts the level of oxygen production in the pond, in addition to other factors such as temperature and salinity. Oxygen production in RAS ponds is also influenced by the 1-2% slope of the pond bottom, which facilitates sediment collection and reduces oxygen consumption for decomposition (Moghbeli et al., 2023; Ruan et al., 2026; Wu et al., 2025).

The main factors influencing oxygen production levels in RAS ponds are water hydrodynamics, shrimp biomass, and water quality (Feng et al., 2025). This is supported by findings from dynamic modeling analysis, which demonstrate an interactive relationship between rotation rate, oxygen transfer rate, and pond water quality. Circulating water currents accelerate turbulence and increase water-air contact, creating a positive feedback loop affecting pond water quality stability. Meanwhile, decreased aeration capacity triggers water degradation due to the reduced oxygen solubility available for decomposing aquaculture waste (Ali, 2022; Jayraj et al., 2025; Kaya et al., 2020). Overall, this study demonstrates that the success of a RAS cultivation system is largely determined by the correlation between the technical aspects of cultivation and the ecological conditions of the water, which influence each other throughout the operational process.

The results of this research confirm that dissolved oxygen is the most important and dominant variable in pond ecosystems, followed by salinity and temperature, which are closely linked. In RAS ponds, these parameters change simultaneously and influence one another (Silva et al., 2025; Mokarram et al., 2025; Hossain et al., 2026). This finding indicates that the effectiveness of a RAS system is determined not only by aeration capacity, but also by the system's ability to maintain hydrodynamic balance so that oxygen distribution occurs evenly throughout the air column. Circulation has the potential to create zones with low oxygen levels (hypoxic microzones), which can inhibit the nitrification process, increase the accumulation of organic matter, and accelerate the decline in air quality (Araujo et al., 2025; Hou et al., 2024; Fu et al., 2024). Therefore, to maintain a stable air system, it is necessary to maintain the effect of the air rotation rate and determine a sufficient number of paddle aerators so that the efficiency of oxygen transfer remains efficient in supporting pond productivity.

CONCLUSION

This study successfully elucidates the mechanisms of oxygen transfer rates and dynamic fluctuations in water quality in shrimp ponds using a Recirculating Aquaculture System through a dynamic modeling approach. The results of the study indicate that the variability in oxygen transfer rates is strongly influenced by the interaction of water hydrodynamic factors, paddle aerator performance, shrimp biomass, and water quality conditions, followed by the justification that salinity and temperature parameters are the dominant indicators controlling the oxygen transfer rate in the pond. The results of the dynamic model simulation describe the synchronization between the rotational speed of the paddle aerator, water circulation patterns, water hydrodynamic factors, and water quality stability and increase the effect of oxygen diffusion in the pond ecosystem. In addition, the cylindrical pond design and the development of a circular flow pattern with the placement of the number of paddle aerators and a symmetrical central drain layout have proven effective in minimizing the occurrence of dead zones and increasing the homogeneity of oxygen distribution in the pond.

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DINAMIČKO MODELIRANJE ANALIZE MEHANIZMA PRIJENOSA KISIKA I DINAMIKE KVALITETE VODE U AKVAKULTURNIM RECIRKULACIJSKIM SUSTAVIMA

SAŽETAK

Otopljeni kisik važan je pokazatelj u intenzivnim sustavima uzgoja škampa. Cilj ove studije je analizirati dinamiku prijenosa kisika i identificirati parametre kvalitete vode koji utječu na razinu kisika u uzgoju škampa, korištenjem akvakulturnog recirkulacijskog sustava (RAS) i pristupa dinamičkog modeliranja sustava. Studija je provedena u šest ribnjaka u Pekalonganu u Indoneziji tijekom operativnog ciklusa RAS-a. Promatrani parametri kvalitete vode bili su pH, temperatura, otopljeni kisik i salinitet dok su brzine prijenosa kisika analizirane primjenom standardnog pristupa brzine prijenosa kisika. Analiza podataka provedena je statističkim testovima i analizom dinamičkog modeliranja sustava. Rezultati su pokazali da su se razine kisika u RAS-u kretale od 1,684 do 3,652 mg O_2/L/sat, s najvišom vrijednošću od 3,195 ± 0,15 mg O_2/L/sat (ribnjak 2). Salinitet je imao najjaču korelaciju s brzinom prijenosa kisika ($r = 0,857$; $p < 0,01$), što ukazuje na njegov dominantan utjecaj na kontrolu difuzije kisika putem viskoznosti vode i performansi lopatičastog aeratora. Rezultati simulacije modela ukazali su na sinkronizaciju između brzine rotacije lopatičastog aeratora, hidrodinamike cirkulacije vode i kvalitete vode, stvarajući pozitivnu povratnu spregu koja povećava brzinu difuzije kisika u ribnjaku. Suprotno tome, smanjeno prozračivanje dovodi do nedostatka kisika i fluktuacija kvalitete vode. Kombinacija ekološkog inženjerskog dizajna, hidrodinamičke optimizacije i upravljanja aeracijom temeljni je čimbenik u operativnom ciklusu RAS-a.

Ključne riječi: difuzija, lopatičasti aerator, ribnjak, škampi

CONFLICT OF INTEREST

The author declares no conflict of interest.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analysed during the current study are not publicly available but are available from the corresponding author upon reasonable request.

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