http://dx.doi.org/10.18623/rvd.v23.6156

THE IMPACT OF FLOATING NET CAGE ACTIVITIES ON THE WATER QUALITY OF CENGKLIK RESERVOIR: ANALYSIS OF BOD, COD, DO, AND TSS FROM SECONDARY DATA

O IMPACTO DAS ATIVIDADES DE CRIADOUROS FLUTUANTES NA QUALIDADE DA ÁGUA DO RESERVATÓRIO DE CENGKLIK: ANÁLISE DE BOD, COD, OD E TSS A PARTIR DE DADOS SECUNDÁRIOS

Article received on: 9/1/2026
Article accepted on: 7/4/2026

Nine Elissa Maharani*
*****Doctoral Program of Environmental Science, School of Postgraduate Studies, Universitas Diponegoro, Semarang, Indonesia
elissanine@gmail.com

Sutrisno Anggoro*
*****Doctoral Program of Environmental Science, School of Postgraduate Studies, Universitas Diponegoro, Semarang, Indonesia
elissanine@gmail.com

Nurjazuli*
*****Doctoral Program of Environmental Science, School of Postgraduate Studies, Universitas Diponegoro; Semarang, Indonesia
elissanine@gmail.com

The authors declare that there is no conflict of interest

Abstract
Cengklik Reservoir in Boyolali, Central Java, has experienced significant water quality degradation due to intensive Floating Net Cage (FNC) activities. Uneaten feed and fish feces that accumulate at the reservoir bottom increase organic matter and nutrient loads, leading to eutrophication and upwelling phenomena that cause mass fish mortality. This study aims to analyze the impact of FNC activities on water quality through Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), and Total Suspended Solids (TSS). Secondary data were obtained from the Bengawan Solo River Basin Authority (BBWS) covering the period 2020–2024, tested using SNI 6989.72:2009, SNI 6989.2:2019, APHA (2017), and an in-house method for TSS. Descriptive analysis was employed to evaluate annual trends and compare them against national standards (Government Regulation No. 22/2021). The results indicate that BOD (3.41–7.9 mg/L) and COD averages consistently exceeded quality thresholds, while DO remain relatively low (<4 mg/L), signaling unhealthy aquatic conditions. TSS values fluctuated but generally stayed below the standard limit. In conclusion, FNC activities significantly contribute to the deterioration of reservoir water

Resumo
A represa de Cengklik, em Boyolali, Java Central, sofreu uma significativa degradação da qualidade da água devido às intensas atividades de criação em gaiolas flutuantes (FNC). Ração não consumida e fezes de peixes que se acumulam no fundo do reservatório aumentam a carga de matéria orgânica e nutrientes, levando à eutrofização e a fenômenos de afloramento que causam mortalidade em massa de peixes. Este estudo tem como objetivo analisar o impacto das atividades de FNC na qualidade da água por meio da Demanda Bioquímica de Oxigênio (DBO), Demanda Química de Oxigênio (DQO), Oxigênio Dissolvido (OD) e Sólidos Suspendidos Totais (SST). Dados secundários foram obtidos da Autoridade da Bacia Hidrográfica do Rio Bengawan Solo (BBWS), abrangendo o período de 2020 a 2024, e testados utilizando as normas SNI 6989.72:2009, SNI 6989.2:2019, APHA (2017) e um método interno para TSS. A análise descritiva foi empregada para avaliar as tendências anuais e compará-las com os padrões nacionais (Regulamento Governamental nº 22/2021). Os resultados indicam que as médias de BOD (3,41–7,9 mg/L) e COD excederam consistentemente os limites de qualidade, enquanto o OD permaneceu

quality. The study implies the urgent need for improved feed management, cage density regulation, continuous monitoring, and stakeholder collaboration to sustain both ecological functions and the socio-economic benefits of Cengklik Reservoir.

Keywords: Floating Net Cage. Water Quality. Cengklik Reservoir.

relativamente baixo (<4 mg/L), sinalizando condições aquáticas insalubres. Os valores de TSS flutuaram, mas geralmente permaneceram abaixo do limite padrão. Em conclusão, as atividades de gaiolas flutuantes contribuem significativamente para a deterioração da qualidade da água do reservatório. O estudo sugere a necessidade urgente de melhoria na gestão da alimentação, regulamentação da densidade das gaiolas, monitoramento contínuo e colaboração das partes interessadas para sustentar tanto as funções ecológicas quanto os benefícios socioeconômicos do Reservatório de Cengklik.

Palavras-chave: *Gaiola Flutuante. Qualidade da Água. Reservatório de Cengklik.*

1 INTRODUCTION

Reservoirs are a vital infrastructure that plays a crucial role in life and development. The functions of reservoirs include providing raw water, supporting agricultural irrigation, controlling floods, generating hydroelectric power, sustaining fisheries, and promoting tourism sector development. The availability of stable water in reservoirs is an aspect of the sustainability of various economic and social activities (Aubin *et al*., 2025).

Reservoirs create new habitats for fish and are often utilized for aquaculture activities, such as the use of floating net cages. Floating Net Cages are fish farming containers that float in waters such as rivers, reservoirs, and lakes. Floating Net Cages are made of rectangular or cylindrical-shaped nets and are equipped with buoys, frames, and anchoring systems to keep them stable. (Rostika *et al*., 2024). The Floating Net Cage serves as a fish rearing facility, allowing water to flow in and out. Thus, there is an exchange with the surrounding waters. Floating Net Cages have several advantages, including not requiring large amounts of land, being easy to maintain, and facilitating easy fish harvesting (Nirmala *et al*., 2023).

Although floating net cage activities carried out in reservoir water bodies have many advantages, they also have a significant negative impact on water quality. (Astuti *et al*., 2023). The positive impact of floating net cage activities is that they serve as a source of animal protein, providing a livelihood for the community around the reservoir. The types of fish cultivated in this cage are tilapia, catfish, and tawes fish. Fish farming in reservoirs using a floating net cage system is not only economically beneficial but also detrimental to water quality. (Warsa *et al*., 2024),Henry *et al*l, 2019., (Awaliyah *et al*., 2019).,Demetrio *et al*l, 2012., Vishnu *et al*., 2019). This is caused by the remaining fish feed that is not eaten and enters the bottom of the reservoir water. Additionally, fish droppings/fish feces that enter the reservoir water also contribute to water pollution and reduce the quality of the reservoir water. (Kumar, 2024). Fish feed contains nitrogen and phosphorus. The rest of the feed that enters the bottom of the reservoir causes the enrichment of nutrients in the water (Tabrett *et al*., 2024). The impact of this nutrient enrichment is the occurrence of eutrophication, a process in which excessive nutrients in a body of water stimulate the growth of algae and aquatic plants (Tahiluddin & Roleda, 2025). In the Cengklik Reservoir, there has been a proliferation of aquatic plants, particularly the growth of water hyacinths. This is what exacerbates the deterioration of water quality conditions (Hudson *et al*., 2008).

Cengklik Reservoir is one of the tourist attractions in Boyolali Regency, specifically located in Ngemplak District, near Sobokerto Village and Ngargorejo Village. This reservoir serves multiple functions, including facilitating transportation, providing irrigation resources, controlling floods, preserving biological resources, and offering a location for fishery cultivation. (Damayanti *et al*., 2019). The Cengklik Reservoir is managed by the Bengawan Solo River Regional Center (BBWS). In this reservoir, fish cultivation is conducted using a Floating Net Cage system. Fish farming using a floating net cage system is one of the primary livelihoods of the community surrounding the reservoir. Floating net cages in the Cengklik reservoir are located in Sobokerto and Ngargorejo villages. There are as many as 40 units of floating net cages in the Cengklik reservoir in Sobokerto Village, and there are 30 floating net cages in the Ngargorejo Village area. (bpusdataru-bs-jatengprov, 2025)

Although numerous studies have explored the relationship between aquaculture and reservoir water quality, most have been limited to short-term monitoring or localized case studies. For example, research by Warsa *et al*. (2024) focused on evaluating aquaculture waste management innovations, while Henry *et al*. (2019) emphasized the sustainability challenges under drought conditions. Awaliyah *et al*. (2019) and Demetrio *et al*. (2012) analyzed fish diet and waste contributions in other tropical reservoirs, but their scope was not extended to multi-parameter chemical analysis over several years. Consequently, there remains a gap in understanding long-term water quality dynamics in reservoirs subjected to continuous FNC operations, particularly in Indonesia. Few studies have systematically analyzed multiple chemical indicators—BOD, COD, DO, and TSS—using longitudinal secondary data to quantify the ecological impact of aquaculture.

This gap is particularly significant for Cengklik Reservoir, which serves as both a livelihood hub and a vulnerable ecosystem. Previous studies have noted the occurrence of eutrophication and mass fish deaths but have not provided an integrated analysis of the main water quality parameters across multiple years. Without such insights, policymaking and stakeholder collaboration may lack the necessary empirical basis to design effective interventions for sustainable aquaculture and water resource management.

Therefore, this study seeks to fill that gap by conducting a descriptive analysis of secondary water quality data from the Bengawan Solo River Basin Authority (BBWS) covering the period 2020–2024. Specifically, it evaluates four critical indicators of water quality: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), and Total Suspended Solids (TSS). By examining five years of data, this research provides a robust understanding of temporal trends and ecological stressors linked to floating net cage activities. Furthermore, the study situates its findings within the broader regulatory framework of Government Regulation No. 22/2021 on Water Quality Protection and Management, thereby ensuring relevance for environmental governance.

In addition to contributing empirical evidence, this research offers practical implications for water resource managers, local government agencies, and aquaculture stakeholders. The analysis not only identifies the extent of pollution but also provides recommendations for managing feed practices, regulating cage density, and implementing sustainable monitoring programs. By highlighting the interplay between aquaculture and ecosystem health, the study aims to support informed decision-making that balances economic benefits with environmental sustainability.

The introduction establishes the importance of reservoirs, outlines the dual impact of FNC aquaculture, identifies the ecological challenges facing Cengklik Reservoir, and highlights the lack of long-term, multi-parameter studies in this context. The purpose of the research is to analyze the impact of floating net cage activities on the water quality of Cengklik Reservoir through BOD, COD, DO, and TSS indicators using secondary data from 2020 to 2024. The findings are expected to strengthen both scientific understanding and practical management strategies for sustainable reservoir ecosystems in Indonesia.

2 METHOD

This research utilized secondary data from the official website of BBWS Bengawan Solo, which is updated annually and monthly. The data in this research were obtained from secondary sources with a 5-year range, specifically from 2020 to 2024, which were collected from January to December. The water quality parameters studied in this research are BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), DO (Dissolved Oxygen), and TSS (Total Suspended Solids).

The procedure for collecting water quality sample data was carried out by the BBWS (River Region Center), Bengawan Solo. Thus, the researcher used secondary data in the research. The sampling procedure was carried out in accordance with Indonesian National Standards (SNI), such as SNI 6989.57:2008, concerning Surface Water Sampling Methods. BBWS also uses the hydrological and water quality information system (SIHKA) to manage and display the collected water quality data. Secondary data can be accessed through the official BBWS website, which is updated monthly for one year. The test method used by BBWS in determining water quality is SNI 6989.72.2009 for BOD testing. For COD testing, the SNI 6989.2.2019 test method was used, while the DO parameter utilizes the APHA 2017 test method, Section 4500. OG. TSS parameters were tested using the In-House Method.

The data analysis method employed in this research was descriptive analysis, which was used to analyze each test parameter, namely BOD, COD, DO, and TSS. Descriptive statistics are presented with annual water quality graphs for these 4 parameters. Temporal trend analysis was presented using line graphs to analyze the trend of water quality change over time. Analysis of comparisons with quality standards. This analysis was used to compare the results of water quality over time and assess them against reservoir water quality standards, as outlined in Government Regulation of the Republic of Indonesia No. 22 of 2021, which concerns the Implementation of Water Quality Protection and Management. In the PP, reservoirs were classified as either class 2 or 3 waters, depending on their designation. Another data analysis in this research involved inferring the impact of floating net cages and the data analysis process, utilizing statistical software such as SPSS and Excel.

3 RESULTS AND DISCUSSION

3.1 General conditions of water quality of Cengklik Reservoir (year 2020-2024)

Table 1

Description of Cengklik Reservoir Water Quality Parameters 2020-2024

Parameter	Unit	Year	n	Min	Max	Mean	Quality Standard (Class II)
BOD	mg/L	2020	10	4,2	14,8	7,9	3mg/L
		2021	12	2,87	13,3	5,6	
		2022	12	1,5	11,6	4,2	
		2023	12	1,7	11,1	3,4	
		2024	12	1,97	25,2	6,2	
COD	mg/L	2020	10	18,7	44,5	29,7	25mg/L
		2021	12	8	51,7	29,9	
		2022	12	12,5	36	23	
		2023	12	12,1	83	29,02	
		2024	12	4,28	60,23	29,3	
OF	mg/L	2020	10	0,4	5,96	3,11	>4mg/L
		2021	12	1,3	8,4	3,90	
		2022	12	0,8	6,4	3,12	
		2023	12	1,8	6,6	4,26	

		2024	12	2,06	6,26	4,51	
TSS	mg/L	2020	10	2	179	26	50mg/L
		2021	12	1	19	7,36	
		2022	12	4	43	13,58	
		2023	12	4	26	9,91	
		2024	12	7	32	18,29	

Based on Table 1, it can be observed that the water quality parameters studied in the Cengklik Reservoir are BOD, COD, DO, and TSS. These parameters are crucial and key indicators of water quality (Woelmer *et al*., 2023), (Carey *et al*., 2022). Water quality parameter data is taken based on secondary data on the official website of BBWS Bengawan Solo. Based on data on BOD (Biochemical Oxygen Demand) parameters in the Cengklik Reservoir over the last 5 years (from 2020 to 2024), it is evident that the average BOD value exceeds all quality standards, with a value of more than 3mg/L. The highest average BOD value over the last 5 years occurred in 2020, at 7.9 mg/L. The lowest average BOD value in the last 5 years occurred in 2022 (May and July), and the highest average BOD value occurred in 2024, which is 25.5 mg/L (July). Biochemical Oxygen Demand (BOD) is a measure used to determine the amount of oxygen needed by microorganisms to decompose organic matter in water. (Cui *et al*., 2025). If the BOD value is high (exceeding the quality standard of Government Regulation of the Republic of Indonesia No. 22 of 2021, which is more than 3 mg/L), then it indicates that the water has a high content of organic matter, such as domestic waste, industrial waste, or agricultural waste. High BOD also indicates that microorganisms in water require a significant amount of oxygen to decompose organic matter, which can reduce the level of dissolved oxygen in the water. Thus, the higher the BOD value in the water, the lower the level of DO/dissolved oxygen in the water. The high BOD content in the water indicates the presence of water pollution by organic matter that affects aquatic life and water quality. (Maddah, 2022); (Vigiak *et al*., 2019).

The Cengklik Reservoir is used for cultivating floating net cages. Leftover uneaten feed and fish droppings/fish feces will directly enter the bottom of the reservoir, causing a buildup of nutrients at the bottom. This is what causes the growth of aquatic weeds to become uncontrollable. In addition, waste from uneaten feed residues and fish droppings pollutes the reservoir water, leading to a decrease in water quality (Uglem *et al*., 2014).

Chemical Oxygen Demand (COD) is the amount of oxygen needed to chemically oxidize organic substances in reservoir water. The high COD content indicates the presence of more organic matter pollution in the reservoir water. This can cause a reduction in dissolved oxygen and also impact aquatic life. The high COD content in the Cengklik Reservoir is also caused by the activity of floating net cages in the reservoir waters. Over the last 5 years, the average COD content in the Cengklik Reservoir has consistently exceeded the set quality standard, which is 25 mg/L. The highest average COD content occurred in 2021, at 29.9 mg/L. The lowest average COD content in 2024 was 4.28 mg/L, and the highest average COD content was recorded in 2024, at 60.23 mg/L. The higher the COD content, the higher the BOD content. High COD levels can lead to a decrease in dissolved oxygen levels in the water, thus endangering aquatic life. Additionally, the high COD content produces unpleasant odors and pollutes the environment.

Dissolved Oxygen (DO) is the amount of oxygen contained in water. This parameter determines the health of the aquatic environment for the organisms that inhabit it. Oxygen can be formed in water due to the photosynthesis of algae, phytoplankton, and aquatic plants. Lack of Do in water can have an impact on hypoxia and the death of organisms (fish). (Jane *et al*., 2023), (Liqoarobby *et al*., 2021). For example, the upwelling phenomenon in the Cengklik Reservoir, which causes mass fish deaths, is also caused by a decrease in the content of DO in the water and ammonia, as well as organic matter at the bottom of the reservoir, which rises to the surface due to extreme weather, so that fish lack oxygen and die en masse.

Total Suspended Soil (TSS) is a total suspended solids in water in the form of organic particles, inorganics, plankton, microorganisms, and mixtures that cannot mix in water. (Chapman *et al*., 2017). The average TSS content in the Cengklik Reservoir over the last 5 years remains below the quality standard value (< 50 mg/L). However, in 2020, the TSS content exceeded the quality standard value, reaching 179 mg/L. The highest average TSS content in the Cengklik Reservoir is expected to occur in 2024, at

18.24 mg/L. Although this value is still below the quality standard of PP No. 22 of 2021, which is approximately 50 mg/L, it pertains to the Implementation of Water Quality Protection and Management. The high content of TSS in reservoir water affects the turbidity and sedimentation of the reservoir water. The high TSS content can also carry nutrients such as phosphate, which triggers the overgrowth of algae (blooming) and water hyacinths, causing eutrophication. If reservoir water is used as raw water, the high TSS content will increase the cost of water treatment. (Adhar *et al*., 2022); (Ahuja *et al*., 2013); (Chernova *et al*., 2022).

3.2 Graph of annual fluctuations and trends of Cengklik Reservoir water quality parameters

3.2.1 Parameter biochemical oxygen demand (BOD)

Figure 1

Average BOD Data for Cengklik Reservoir in 2020

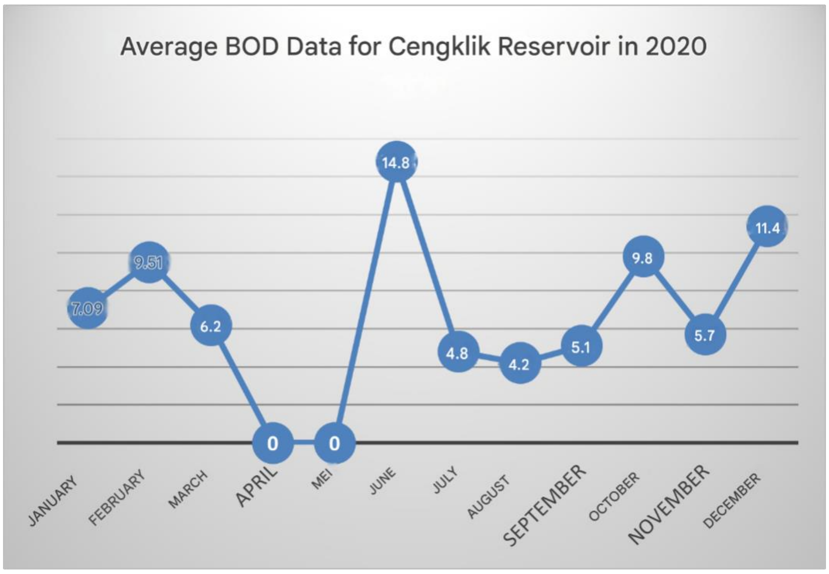


Figure 2

Average BOD Content Data for 2021

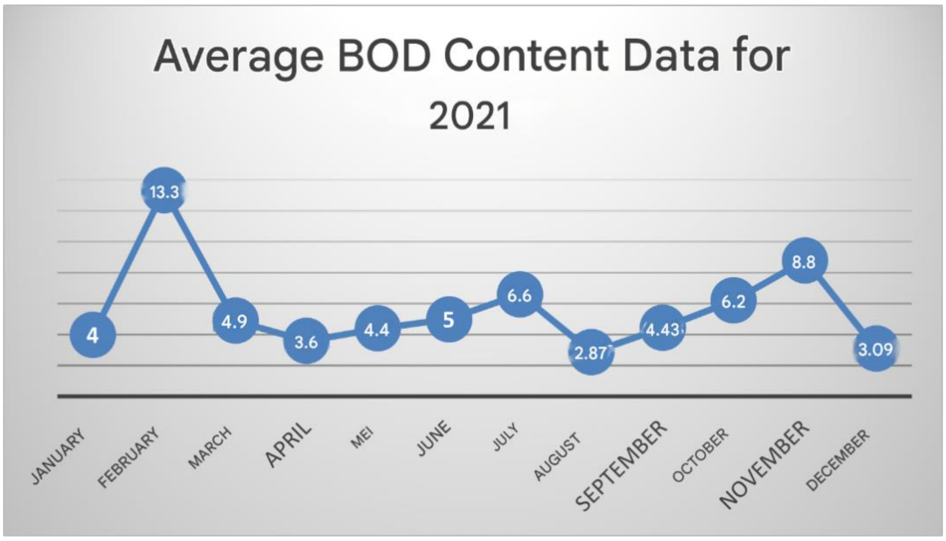


Figure 3

BOD Content Data 2022 BOD Content (mg/L)

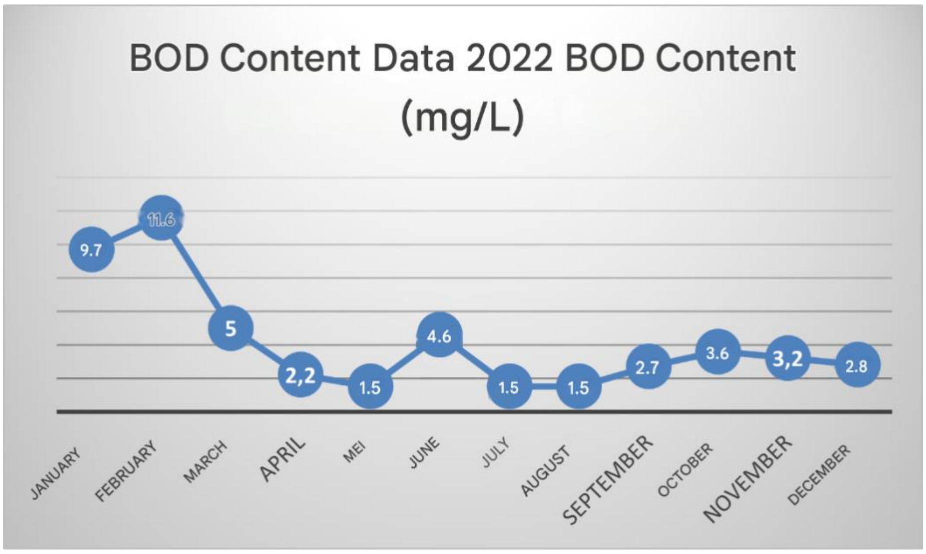


Figure 4

BOD Content Data 2023 BOD Content (mg/L)

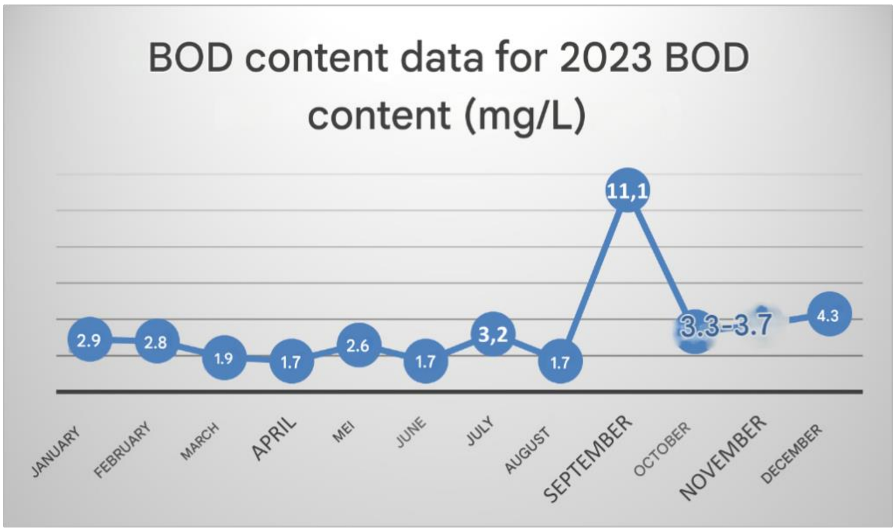
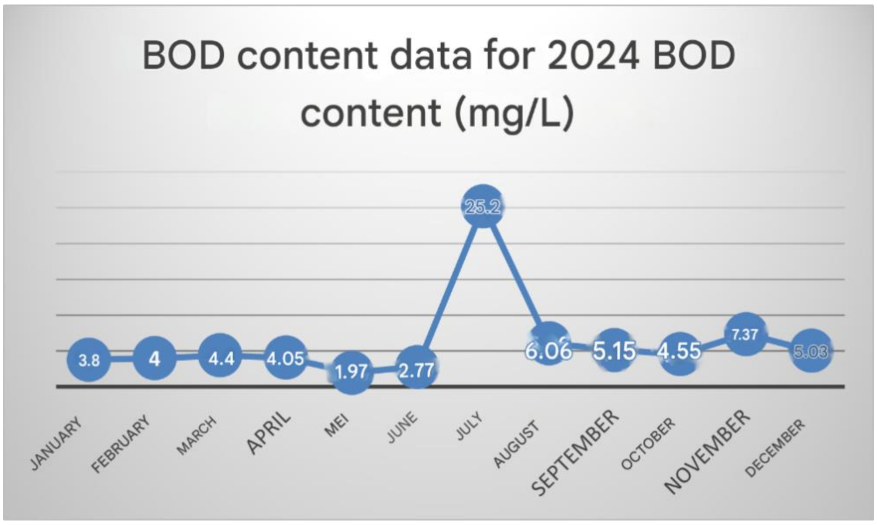


Figure 5

BOD Content Data 2024 BOD Content (mg/L)



Based on the graph of BOD content for the last 5 years in the Cengklik Reservoir, it is evident that the BOD level has exceeded the set quality standard of more than 3 mg/L for the past 5 years. The average BOD content ranges from 3.41 to 7.9 mg/L. The highest BOD content is expected to occur in July 2024, at 25.2 mg/L. High BOD also indicates that microorganisms in water require a significant amount of oxygen to decompose organic matter, which can reduce the level of dissolved oxygen in the water. Thus, the higher the BOD value in the water, the lower the level of DO/dissolved oxygen in the water. High BOD content in water indicates the presence of water pollution by organic matter that affects aquatic life and water quality.

3.2.2 Parameter COD

Figure 6

COD Content Data 2020 COD Content (mg/L)

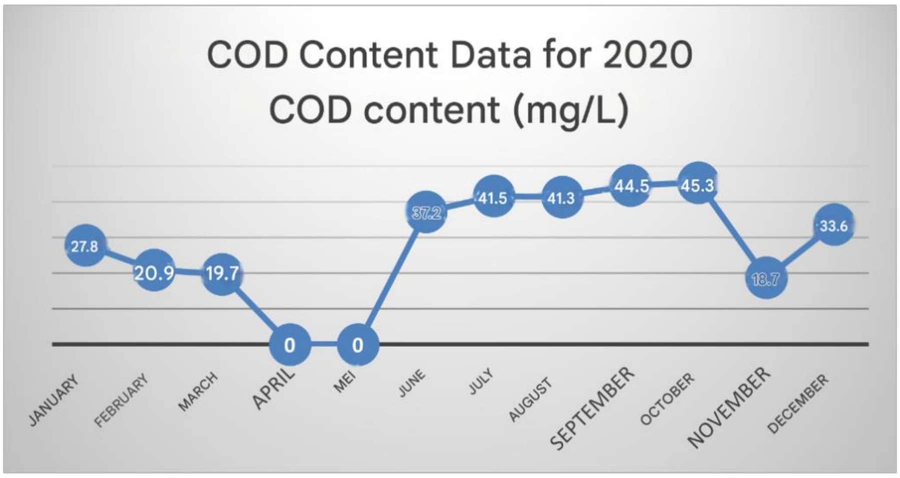


Figure 7

COD Content Data 2021 COD Content (mg/L)

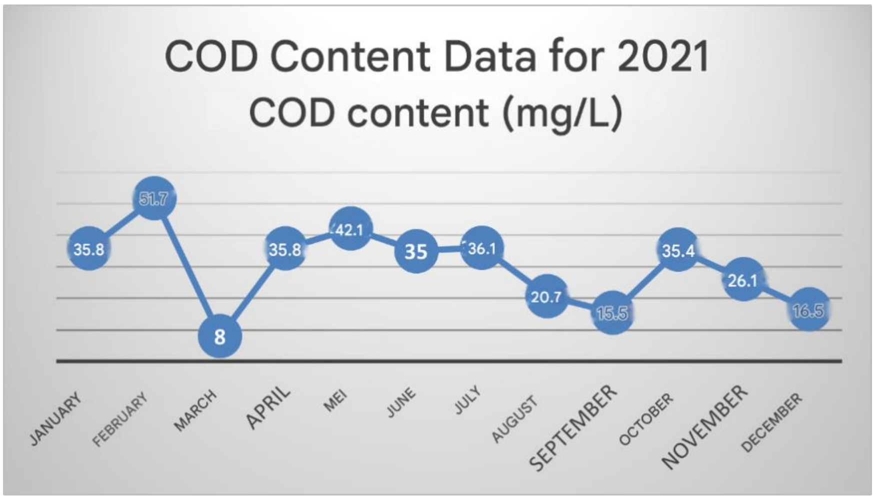


Figure 8

COD Content Data 2022 COD Content (mg/L)

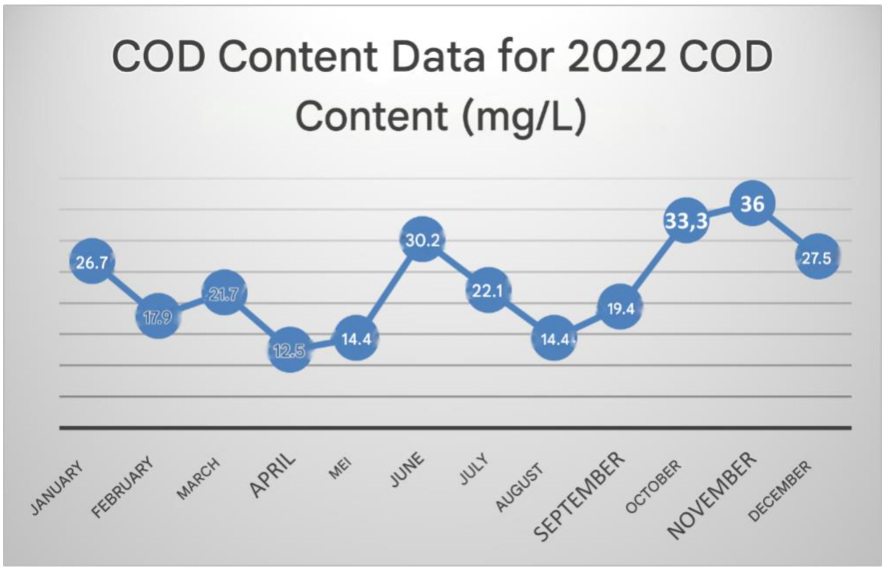


Figure 9

COD Content Data 2023 COD Content (mg/L)

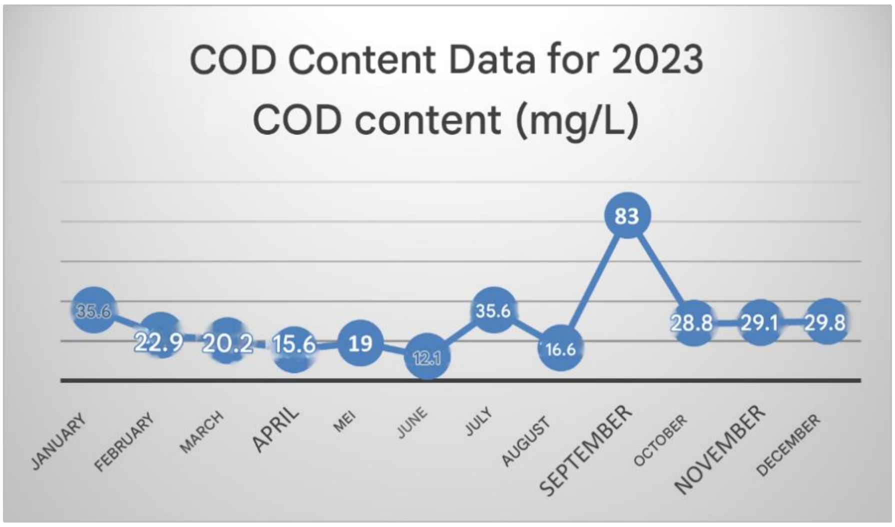
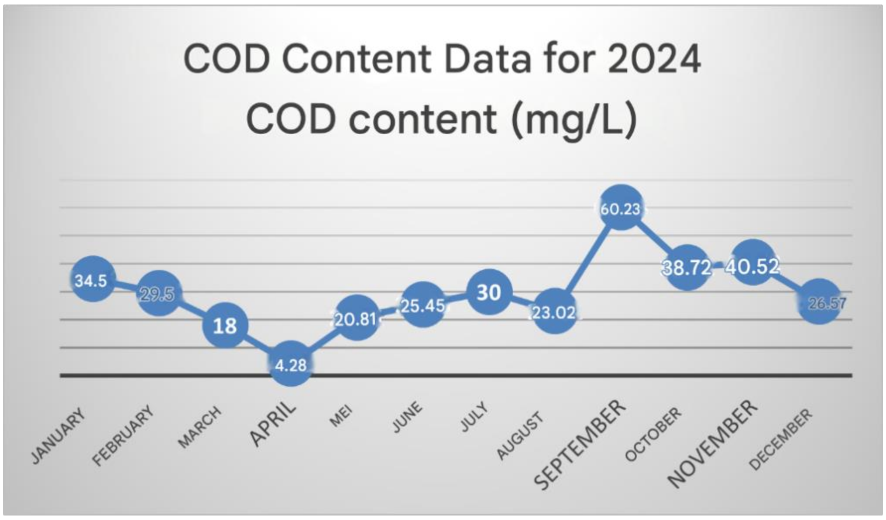


Figure 10

COD Content Data 2024 COD Content (mg/L)

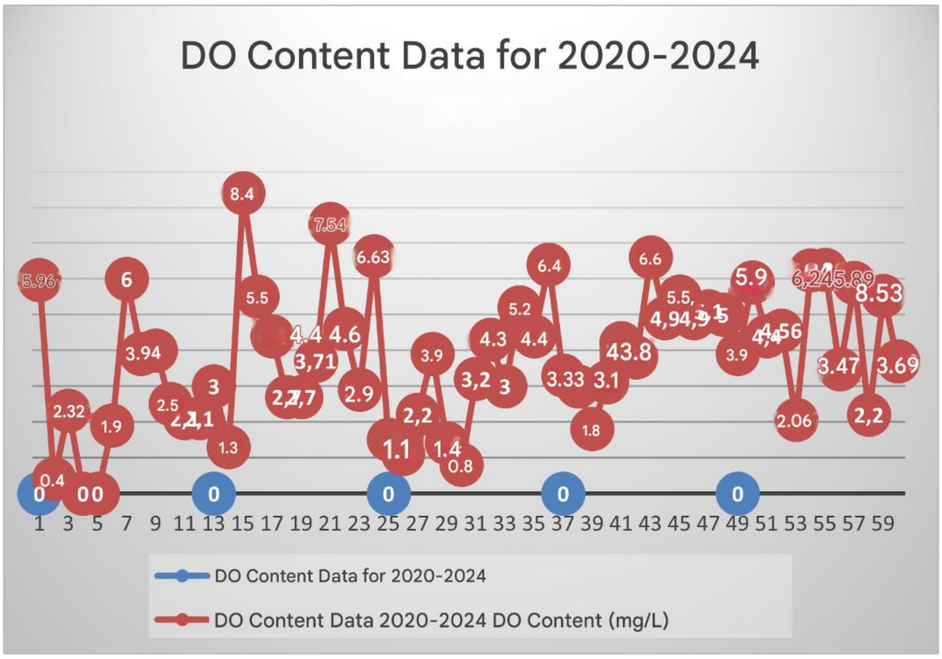


The COD content in the Cengklik Reservoir has consistently met the standard, which is no more than 25 mg/L, over the last 5 years (2020-2024). The highest average COD content was 29.9 mg/L, occurring in 2021. However, the highest COD content in the Cengklik Reservoir was recorded in September 2023, at 83 mg/L. September is the rainy season, thus, a lot of pollutant loads enter the reservoir flow. In addition, high COD can also come from agricultural runoff (fertilizers and pesticides), cage activities. The higher the COD, the lower the level of DO (dissolved oxygen) in the water. This is because the higher the COD, the more oxygen is required to break down pollutants, resulting in a decrease in dissolved oxygen (DO) in the water.

3.3 DO content data for 2020-2024

Figure 11

DO Content Data 2020-2024

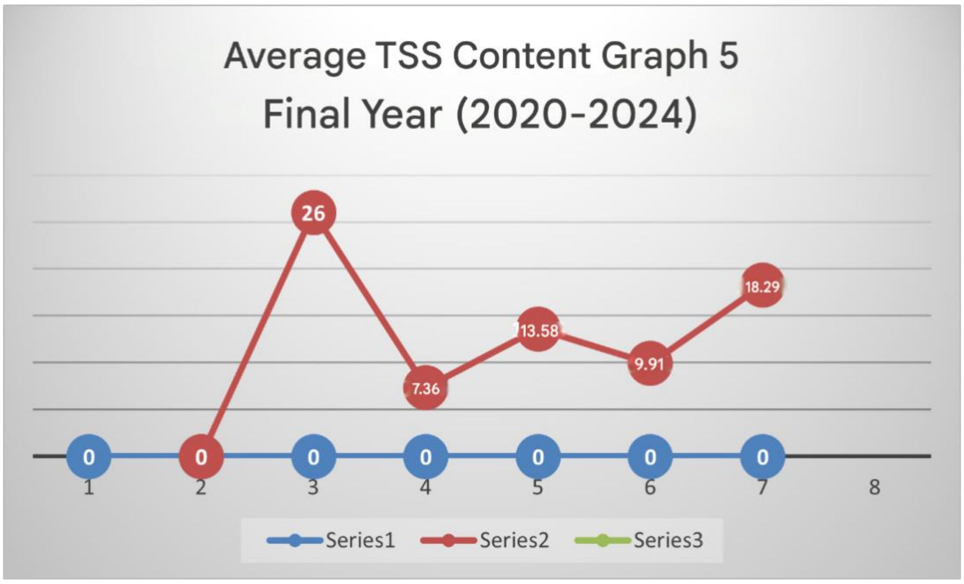


Based on the graph of DO content in the Cengklik Reservoir in 2020-2024, it can be seen that the highest DO content was only 8.4 mg/L and occurred in March 2021. The standard of quality for DO content is greater than 4 mg/L. At DO content levels of 4 mg/L, fish farming in Karamba can run smoothly and remain healthy. If the DO content is less than 4 mg/L, it can be concluded that the reservoir waters are unhealthy due to a lack of oxygen. The oxygen content present in reservoir water is utilized by microorganisms to sustain life and reproduce. If the reservoir water has a low dissolved oxygen content (DO < 4 mg/L), anoxic conditions will occur. This anoxic condition will be fatal if accompanied by extreme weather that causes organic matter, such as phosphate, nitrates (organic matter left over from fish feces and fish waste), and ammonia, to rise to the surface of the water. (Carey *et al*., 2022), (Zeman-Kuhnert, 2022). As a result of this event, a phenomenon known as upwelling will occur, leading to mass fish deaths. Based on this graph, the average DO content in the waters of Cengklik Reservoir over the last 5 years ranges from 3.11 to 4.51 mg/L. This means that the DO content in Cengklik Reservoir is relatively low. The low content of DO in the waters of the Cengklik Reservoir indicates that many organic materials cause water pollution in the reservoir. One of the sources of water pollution in the Cengklik Reservoir is the activities of KJA (Floating Net Cages), which result in leftover feed that is not eaten and fish feces that are discharged directly into the bottom of the reservoir. Additionally, anthropogenic activities from the surrounding community also contribute to water pollution in the Cengklik reservoir. For example, agricultural activities on the outskirts of reservoirs that use pesticides can lead to pesticide residues directly entering the soil and reservoir water. Culinary business activities along the periphery of the reservoir that produce liquid waste, and the waste is directly drained into the reservoir water body. This contributes to the pollution burden in the Cengklik Reservoir.

3.4 TSS content data in the last 5 years (2020-2024)

Figure 12

Average TSS Content Graph 5 Final Year (2020-2024)



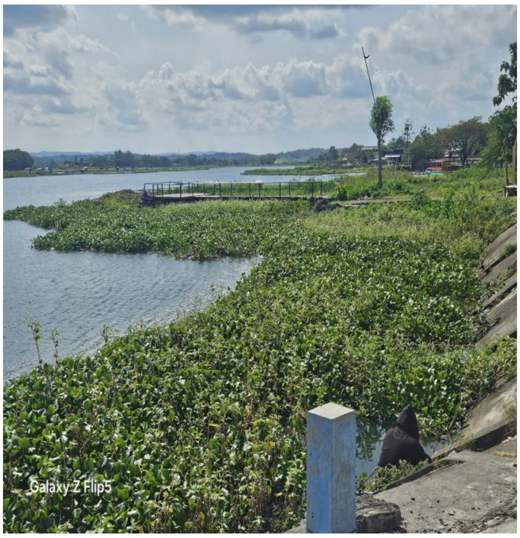
Based on the figure 12 above, which shows the average TSS content in the Cengklik Reservoir over the last 5 years, the highest average TSS was recorded in 2020 at 26 mg/L, while the lowest TSS content was observed in 2021 at 7.36 mg/L. The average TSS content in the Cengklik Reservoir over the last 5 years is still below the quality standard (which is < 50 mg/L). TSS levels below the quality standard indicate that the number of solid particles in the water is also low, resulting in clearer and less cloudy water. The content of TSS that is below the quality standard is suitable for various human needs, such as irrigation, industry, and consumption after further processing. Low TSS (below quality standards) also supports the growth and survival of fish and other aquatic organisms.

3.5 Pollution impact mechanism

The waters of the Cengklik Reservoir also experienced water hyacinth invasions. Water hyacinths that grow uncontrollably in reservoir water occur due to the entry of excessive nutrients from fish feed. Fish feed contains phosphates and nitrates that enter the waters. This nutrient becomes fertilizer for aquatic plants (in this case, water hyacinths). Excessive nutrients trigger the rapid growth of phytoplankton and aquatic plants, including water hyacinths. Uncontrolled growth of water hyacinths causes them to die (Jha & Li, 2025). Decomposing bacteria will decompose the biomass of dead water hyacinths. This decomposition process requires dissolved oxygen (DO). As a result, the level of DO in the water decreased significantly. This leads to the death of fish and other organisms. Anoxic conditions can also exacerbate the impact on aquatic life (Schofield & Mothersill, 2023)

Figure 13

The Expanse of Water Hyacinth at Cengklik Reservoir



4 CONCLUSION

Based on the data previously presented, it can be concluded that the content of BOD, COD, and DO is a key parameter in determining water quality. In this case, it is reservoir water in the Cengklik Reservoir. The content of BOD in the last 5 years has all exceeded the set quality standards. The content of COD in the last 5 years is still below the permissible quality standard value. Meanwhile, the value of DO (dissolved oxygen) content remains relatively low, as it is less than 4 mg/L. The high levels of these parameters are attributed to anthropogenic activities in the community surrounding the reservoir. One example is the floating net cage activities that produce residual feed residue and enter the bottom of the reservoir, as well as fish droppings that also enter the bottom of the reservoir. Thus, the activity of floating net cages is significantly correlated with the degradation of the water quality of the Cengklik Reservoir. Other anthropogenic activities include agricultural practices that generate residues in the form of pesticides and fertilizers, as well as waste from culinary businesses that directly enter the reservoir water body. The impact of water pollution on reservoir ecosystems leads to mass fish deaths and reduced biodiversity. Based on these findings, the following recommendations are proposed: regulating the density of floating net cages, improving feed management, implementing sustainable water quality monitoring programs, and fostering cooperation among stakeholders.

REFERENCES

Adhar, S., Khalil, M., Ayuzar, E., & Rusydi, R. (2022). Influence of rainfall and spatial temporal distribution analysis of total suspended solid in Laut Tawar Lake. *IOP Conference Series: Earth and Environmental Science*, *1062*(1), 12022. https://doi.org/10.1088/1755-1315/1062/1/012022

Ahuja, S., Aiken, G. R., Alcantar, N. A., Alexander, R. B., Andrew, R., Antoniou, M. G., Aponte-Morales, V., Asolekar, S. R., Auer, M. T., & Auer, N. A. (2013). J Adams (Volume 2) US Environmental Protection Agency, Cincinnati, OH, USA T Ahmed (Volume 1) BUET, Dhaka, Bangladesh. *Comprehensive Water Quality and Purification*.

Astuti, L. P., Warsa, A., Sentosa, A. A., & HENDRO, D. W. (2023). Phytoremediation for Nutrient Removal in an Environmentally Friendly Floating Cage System: A Field Experiment. *Sains Malaysiana*, *52*(10), 2761–2772.

Aubin, V., Helseth, A., Korpås, M., & Fleten, S.-E. (2025). Whose heads are we keeping above water? Impacts of risk aversion on hydropower medium-term scheduling. *Authorea Preprints*.

Awaliyah, F., Gunawan, W., & Tasrif, M. (2019). Analysis of changes in water quality used for supporting fish productivity of floating cage/KJA (Keramba Jaring Apung) in Cirata Reservoir. *IOP Conference Series: Earth and Environmental Science*, *306*(1), 12014.

Carey, C. C., Hanson, P. C., Thomas, R. Q., Gerling, A. B., Hounshell, A. G., Lewis, A. S. L., Lofton, M. E., McClure, R. P., Wander, H. L., & Woelmer, W. M. (2022). Anoxia decreases the magnitude of the carbon, nitrogen, and phosphorus sink in freshwaters. *Global Change Biology*, *28*(16), 4861–4881. https://doi.org/10.1111/gcb.16228

Chapman, P. M., Hayward, A., & Faithful, J. (2017). Total suspended solids effects on freshwater lake biota other than fish. *Bulletin of Environmental Contamination and Toxicology*, *99*(4), 423–427.

Chernova, O., Vytyaz, O., Martyniuk, R., & Fedorovych, I. (2022). Rational methods of operation of underground gas storages and mitigation of energy losses. *Nafta-Gaz*, *78*.

Cui, D., Yang, S., Song, X., Huang, X., Duan, C., Ji, M., Li, Z., Yu, S., Deng, Z., & Ke, P. (2025). Monthly methane emissions in Chinese mainland provinces from 2013–2022. *Scientific Data*, *12*(1), 948.

Damayanti, T., Pradipta, J., Rahmawati, I., Harlivasari, A. D., Prasetyo, E., & Anggara, B. (2019). Survey of Lung Function and Respiratory Symptoms Among Online Motorcycle Taxi Drivers in Bekasi City. *Jurnal Respirologi Indonesia*, *39*(1), 54–59.

Hudson, N., Baker, A., Ward, D., Reynolds, D. M., Brunsdon, C., Carliell-Marquet, C., & Browning, S. (2008). Can fluorescence spectrometry be used as a surrogate for the Biochemical Oxygen Demand (BOD) test in water quality assessment? An example from South West England. *Science of the Total Environment*, *391*(1), 149–158.

Jane, S. F., Mincer, J. L., Lau, M. P., Lewis, A. S. L., Stetler, J. T., & Rose, K. C. (2023). Longer duration of seasonal stratification contributes to widespread increases in lake hypoxia and anoxia. *Global Change Biology*, *29*(4), 1009–1023. https://doi.org/10.1111/gcb.16525

Jha, R. R., & Li, D. (2025). Quantifying the effects of water hyacinth (Pontederia crassipes) on freshwater ecosystems: a meta-analysis. *Biological Invasions*, *27*(1), 27.

Kumar, V. (2024). *Feed and feeding for fish and shellfish: nutritional management*. Elsevier.

Liqoarobby, R., Suparman, Y., & Fadilah, K. (2021). Aqueous systems of dissolved oxygen in reservoir. *E3S Web of Conferences*, *249*, 3015.

Maddah, H. A. (2022). Predicting optimum dilution factors for BOD sampling and desired dissolved oxygen for controlling organic contamination in various wastewaters. *International Journal of Chemical Engineering*, *2022*(1), 8637064. https://doi.org/10.1155/2022/8637064

Nirmala, L., Jeya, A., Ramesh, A., Jose, M., Wilson, S. S., Jamuna, A. S., Geena, K. M., & Asokan, A. (2023). Analysis of the drinking water quality and socioeconomic status of the community living in Poonthura, Thiruvananthapuram, India. *International Journal of Ecology and Environmental Sciences*, *49*(4), 417–423.

Rostika, R., Maulida, Y., Zidni, I., Cu, M. I., Khan, A. M., & Pasaribu, B. (2024). Growth and Gastrointestinal Conditions of Green Lobster (Panulirus homarus) With Different Natural Feeding, Which are Raised in a Longline Submerged Cage System on the East Coast of Pangandaran Regency. *Journal Transnational Universal Studies*, *2*(2), 98–109.

Schofield, P. N., & Mothersill, C. E. (2023). *Environmental Radiobiology*. CRC Press.

Tabrett, S., Ramsay, I., Paterson, B., & Burford, M. A. (2024). A review of the benefits and limitations of waste nutrient treatment in aquaculture pond facilities. *Reviews in Aquaculture*, *16*(4), 1766–1786. https://doi.org/10.1111/raq.12921

Tahiluddin, A. B., & Roleda, M. Y. (2025). Current status of eucheumatoid seaweed farming in Tawi-Tawi, Philippines. In *Biotechnological Interventions to Aid Commercial Seaweed Farming* (pp. 95–124). Springer.

Uglem, I., Karlsen, Ø., Sanchez-Jerez, P., & Sæther, B.-S. (2014). Impacts of wild fishes attracted to open-cage salmonid farms in Norway. *Aquaculture Environment Interactions*, *6*(1), 91–103.

Vigiak, O., Grizzetti, B., Udias-Moinelo, A., Zanni, M., Dorati, C., Bouraoui, F., & Pistocchi, A. (2019). Predicting biochemical oxygen demand in European freshwater bodies. *Science of the Total Environment*, *666*, 1089–1105.

Warsa, A., Tjahjo, D. W. H., & Astuti, L. P. (2024). Study of the effectiveness of wasted container bags in SMART floating net cage culture system. *IOP Conference Series: Earth and Environmental Science*, *1436*(1), 12023.

Woelmer, W. M., Hounshell, A. G., Lofton, M. E., Wander, H. L., Lewis, A. S. L., Scott, D., & Carey, C. C. (2023). The importance of time and space in biogeochemical heterogeneity and processing along the reservoir ecosystem continuum. *Aquatic Sciences*, *85*(2), 66.

Zeman-Kuhnert, S. (2022). *Use of selected anthropogenic pesticides, nutrients, and biomarkers to spatially and temporally characterize eutrophication dynamics at a shallow lake (Lake Seeburg).*