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Assessment of Environmental Pollution Potential Due to Effluent from Catfish Aquaculture Ponds in an Integrated Chicken-Fish Farming System in Blitar Regency

Evaluasi Potensi Pencemaran Lingkungan Akibat Efluen Air Kolam Budidaya Lele pada Sistem Peternakan Ayam-Ikan Terpadu di Kabupaten Blitar

EFADESWARNI[1,2*], BUDI KURNIAWAN[3], AND HURIP PRATOMO[4]

[1]Master of Fisheries Management, Graduate School Building, Universitas Terbuka, Jalan Cabe Raya, Pondok Cabe, Pamulang, South Tangerang, Banten, Indonesia 15437

[2]Research Center for Environmental and Clean Technologies, National Research and Innovation Agency (BRIN), B.J. Habibie Science dan Technology Area, Serpong, South Tangerang, Banten, Indonesia, 15314

[3]Research Center for Limnology and Water Resources – National Research and Innovation Agency (BRIN), Cibinong Science Center Complex, Jalan Raya Jakarta-Bogor Kilometer 46, Cibinong, Bogor, West Java Province, Indonesia 16911

[4]Biology Study Program – Faculty of Science and Technology, Universitas Terbuka, Faculty of Science and Technology Building (Building II), Jalan Cabe Raya, Pondok Cabe, Pamulang, South Tangerang, Banten, Indonesia 15418

*deswandi.fitriawan@yahoo.co.id

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ABSTRAK

Sistem pertanian terpadu ayam-ikan merupakan model agroekologis yang menggabungkan pemeliharaan ayam petelur dan budidaya ikan lele dalam satu siklus produksi. Sistem ini mampu menurunkan biaya pakan hingga 30–40% melalui pemanfaatan kotoran ayam sebagai sumber nutrien bagi ikan. Meskipun memberikan manfaat ekonomi, sistem ini memiliki potensi risiko lingkungan yang signifikan apabila air kolam tidak dikelola dengan baik. Penelitian ini bertujuan untuk mengevaluasi potensi pencemaran dari buangan air kolam lele dalam sistem terpadu di Kabupaten Blitar dengan menganalisis parameter kualitas air, meliputi pH, suhu, oksigen terlarut (DO), total padatan terlarut (TDS), total padatan tersuspensi (TSS), kebutuhan oksigen biologis (BOD), kebutuhan oksigen kimiawi (COD), amonia, nitrat, nitrogen total (TN), fosfat total (TP), dan fecal coliform. Studi dilakukan di tiga lokasi, masing-masing terdiri atas dua kolam terpadu, satu kolam kontrol, dan satu sumber air baku. Kolam terpadu menunjukkan kadar BOD, COD, dan fecal coliform tertinggi, yang mengindikasikan kontaminasi organik dan mikrobiologis yang signifikan. Uji-t independen menunjukkan perbedaan signifikan (p<0,05) antara kolam terpadu dan kolam kontrol, sedangkan kolam kontrol tidak berbeda signifikan dengan air baku. Berdasarkan Indeks Pencemar (IP) yang dihitung mengacu pada Kepmen LH No. 115/2003, seluruh kolam terpadu diklasifikasikan dalam kategori tercemar berat (IP>10), dengan beberapa nilai melebihi 2200. Studi ini memberikan kontribusi baru melalui penerapan analisis kuantitatif dan klasifikasi indeks pencemaran pada model budidaya yang masih jarang diteliti, serta menegaskan pentingnya penerapan strategi pengolahan air limbah untuk menjaga keberlanjutan lingkungan dalam praktik akuakultur terpadu.

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ABSTRACT

The integrated chicken-fish farming system is an agroecological model that combines layer chicken rearing and catfish aquaculture within a single production cycle. This system reduces feed costs by up to 30–40% through the utilization of chicken manure as a nutrient source for fish. Despite its economic benefits, the system poses a significant environmental risk if pond water is not managed correctly. This study aimed to evaluate the pollution potential of catfish pond effluents within integrated systems in Blitar Regency by analyzing key water quality parameters, including pH, temperature, dissolved oxygen (DO), total dissolved solids (TDS), total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia, nitrate, total nitrogen (TN), total phosphate (TP), and fecal coliform. The study was conducted at three sites, each comprising two integrated ponds, one control pond, and one raw water source. The integrated ponds exhibited the highest BOD, COD, and fecal coliform levels, indicating substantial organic and microbial contamination. Independent t-tests revealed significant differences (p<0.05) between integrated and control ponds, while control ponds showed no significant difference from raw water. Based on the Pollution Index (PI) calculated using the Decree of Minister of Environment of The Republic of Indonesia Number 115 of 2003, all integrated ponds were classified as heavily polluted (PI>10), with some values exceeding 2200. This study provides a novel contribution by applying quantitative pollution indexing to a rarely assessed farming model, offering empirical evidence that supports the urgent need for wastewater treatment strategies to ensure the environmental sustainability of integrated aquaculture practices.

1. INTRODUCTION

1.1 Background

The environment, particularly surface water components such as rivers, is highly vulnerable to pollution caused by human (anthropogenic) activities (Adji et al., 2023). One of the primary causes of environmental pollution is the improper discharge of untreated organic waste from the livestock sector, particularly animal manure and leftover feed, which directly enters the environment Rivers, as one of the key surface water components, play a vital role in maintaining ecosystem sustainability and meeting human needs, including for consumption, irrigation, and other economic activities. However, river water quality is increasingly degraded due to pressure from anthropogenic activities, including domestic, agricultural, and livestock waste. Livestock activities also generate significant nutrient loads, including nitrogen and phosphate compounds, which can lead to water quality degradation and eutrophication if not effectively managed (Adji et al., 2023; Suada & Tenaya, 2023).

In Indonesia, water pollution caused by livestock activities has reached an alarming level, as indicated by studies on several major rivers. For example, the Citarum River in West Java has shown an increase in BOD levels exceeding 80 mg/L and COD reaching 250 mg/L—far above the Class II water quality standards set by Government Regulation No. 22 of 2021, which stipulate maximum limits of 3 mg/L for BOD and 25 mg/L for COD (Kamila et al., 2024). A similar situation also occurs in the Code River in Yogyakarta, where BOD levels have been recorded ranging from 20 to 40 mg/L at several monitoring points (DLHK DIY, 2023).

However, pollution can be minimized by implementing environmentally friendly farming systems, such as using tarpaulin or earthen ponds, applying natural mixed feed, and avoiding excessive use of antibiotics and artificial feed. With this approach, the organic waste remains within the environmental tolerance limits and can degrade naturally (Fuadi & Sami, 2020; Saifullah, 2021; Zaidy, 2022).

The integrated chicken-fish farming system is one form of farming system that emphasizes resource efficiency and a circular economy. This system combines layer chicken rearing with catfish cultivation in a mutually beneficial setup. The main advantage of this system is its ability to reduce feed waste and chicken manure by converting them into a direct source of nutrients for the fish, thereby lowering feed costs by 30–40% (Puspitasari et al., 2022). In addition, this system supports land and energy efficiency while enhancing overall land productivity. As a result, it is increasingly being adopted in various regions of Indonesia, including Blitar Regency, as a cost-effective and sustainable farming solution for small-scale farmers (Srirahayu & Adi, 2021).

Blitar Regency is an area with several advantages, including a stable tropical climate, fertile soil in the northern region due to the influence of Mount Kelud, and supportive infrastructure and socio-cultural conditions conducive to the development of sustainable farming systems (Nurlaili R & Ulfa B.A, 2019). The integrated chicken–fish farming system in Blitar demonstrates high economic potential through the utilization of chicken waste as a natural nutrient source for catfish in integrated ponds, where poultry waste is managed to support catfish aquaculture productivity sustainably (Yakin et al., 2020).

Nevertheless, behind its efficiency, the integrated chicken-fish farming system also carries a significant potential for environmental pollution if not accompanied by proper pond water management. Although chicken manure and leftover feed serve as nutrient sources, they also contribute to accumulating organic matter, nitrogen, phosphate, and ammonia in the pond (Dewa et al., 2022). If the pond water is discharged or overflows into the surrounding environment without treatment, it can pollute water bodies such as rivers and agricultural land. Research by Hapsari et al. (2021) showed that overflow from integrated chicken–fish ponds can significantly increase levels of BOD, ammonia, and total nitrogen, contributing to the deterioration of water quality and accelerating the eutrophication process in receiving water bodies.

The main issue with the integrated chicken-fish farming system lies in its potential to cause environmental pollution due to the discharge or overflow of catfish pond water that is not managed correctly. In field practice, especially in open systems without wastewater treatment facilities, pond water rich in organic matter, nitrogen, and phosphate can flow directly into rivers or seep into surrounding agricultural land. Therefore, a comprehensive assessment is needed to identify the water quality parameters most likely to contribute to environmental pollution and to evaluate the extent of the potential impact, both technically and ecologically.

Several previous studies, such as Hapsari et al. (2021), have examined the integrated chicken-fish farming system regarding feed efficiency and the potential pollution from organic matter and ammonia. However, this study offers a new contribution by quantitatively measuring pollutant parameters, evaluating the pollution level of integrated chicken-fish pond water based on water quality standards according to Government Regulation No. 22 of 2021, and applying the Pollution Index method to assess pollution levels comprehensively. The results of this evaluation are expected to serve as a scientific basis for formulating appropriate and practical water quality management measures to support sustainable and environmentally friendly integrated chicken-fish farming practices.

Despite its increasing application in Indonesia, especially in smallholder farms, the environmental impact of integrated chicken-fish systems remains insufficiently studied, particularly in nutrient buildup and pollution index classification based on regulatory standards. This study offers a novel contribution by applying a comprehensive quantitative analysis and Pollution Index assessment to evaluate the pollution potential of pond effluents. Addressing this research gap is urgent to provide scientific evidence that supports sustainable aquaculture practices and informs proper wastewater management strategies.

1.2 Research Objectives

This study aims to evaluate water quality parameters and analyze the extent of potential pollution caused by the discharge or overflow of catfish pond water in the integrated chicken-fish farming system on the surrounding environment.

2. METHODS

This study employed a quantitative descriptive approach using a case study method at an integrated chicken-catfish farming system in Blitar Regency, East Java. Water sampling was conducted at three main points:

- Raw water (inflow source),
- Integrated pond water (located in a chicken-catfish system), and
- Control pond water (catfish-only system without poultry integration).

Samples were taken randomly from three ponds at a farm using a composite sampling method, The parameters analyzed included physical parameters: temperature, TDS, and TSS; and chemical parameters: pH, DO, BOD, COD, ammonia, nitrate, TN, and TP.

All laboratory analyses followed standard procedures based on APHA (2023) guidelines. Instrument calibration, blank controls, and certified reference standards were applied to ensure data quality through Quality Assurance and Quality Control (QA/QC) protocols.

Water quality results were compared to the surface water quality standards (Class III) according to Government Regulation No. 22 of 2021. Descriptive statistical analysis was used to interpret the results and assess the pollution potential of each pond system. Pollution assessment was conducted using two analytical approaches: threshold comparison approach following the method by Suada & Tenaya (2023) and Pollution Index (PI) method based on Decree of Minister of Environment of The Republic of Indonesia Number 115 of 2003.

To calculate the Pollution Index, the Nemerow Index formula was applied based on the ratio of pollutant concentration to water quality standard (Ci/Li). The steps were as follows: Identify parameters and their applicable quality standards; Calculate the ratio Ci/Li for each parameter at each sampling site; If Ci/Li ≤ 1.0, the original value was used; If Ci/Li > 1.0, the value was adjusted using the formula: (Ci/Li)new = 1.0 + P × log(Ci/Li measured); Compute the average (Ci/Li) R and maximum (Ci/Li)M values; Finally, determine the Pollution Index (PI) using the Nemerow equation (Dey, M. *et al.*, 2021):

$$Pij = \sqrt{((\mathrm{Ci/Li})\mathrm{M}^{2} + (\mathrm{Ci/Li})\mathrm{R}^{2})/2} \quad (1)$$

The resulting PI values were then interpreted to classify the water's pollution level according to predefined categories: unpolluted, lightly polluted, moderately polluted, or heavily polluted.

3. RESULTS AND DISCUSSION

3.1 Description of Research Location

The spatial distribution of the sampling locations is presented in Figure 1. The map shows the geographical positions of Tegal Rejo, Talun, and Sawentar Villages in Blitar Regency, East Java. Each site represents a different pond condition within the household-scale integrated chicken–fish farming system, selected to capture variations in environmental parameters and operational practices. These mapped locations serve as key reference points for understanding spatial differences in effluent quality and pollution potential.

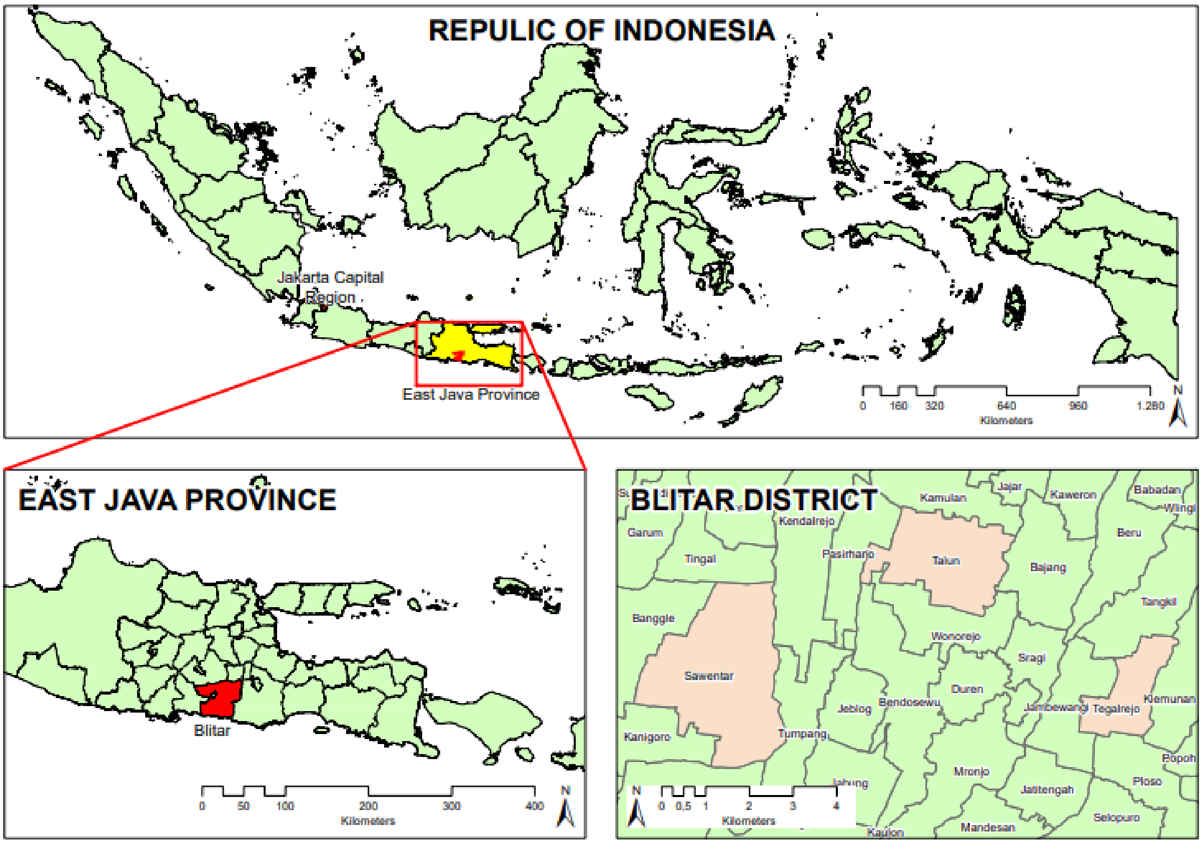

Figure 1. Spatial distribution of sampling locations

As shown in Figure 1, the sampling locations represent distinct pond conditions across three integrated chicken-fish farming sites. The specific characteristics of each site are described as follows. Location Tegal Rejo (Integrated Pond): The pond is located directly beneath a high-density chicken coop (>100 chickens), with no aeration system and only a direct overflow channel leading to nearby rice fields. This site represents a high pollution risk due to the accumulation of chicken manure and leftover feed. The water in this pond appeared murky brown with a foul odor, indicating high organic matter concentration.

Location Talun (Integrated Pond): The pond is situated beneath a medium-density chicken coop (±80 chickens), equipped with a simple waste gutter and basic filtration system. Pond water is occasionally discharged into a drainage ditch connected to a small river. This location represents a semi-managed system. The water showed a dark greenish color, with occasional algal blooms and moderate turbidity;

Location Sawentar (Control Pond): This is a fish pond without integrated poultry housing, although it may still receive runoff from nearby agricultural areas where fertilizers are applied. The water is manually managed through periodic dilution and partial replacement. This location represents the risk of indirect pollution from the surrounding environment. The pond water appears light green with visible suspended particles, indicating a moderate level of nutrient accumulation.

These three locations were selected purposively to reflect the variations in pond water management practices commonly found in integrated chicken-fish systems in Blitar, as well as to evaluate the potential pollution levels based on real field conditions.

3.2 Characterization of Water Quality Parameters

The actual conditions of several physical, chemical, and biological parameters were characterized for raw, integrated, and control pond water. This was carried out to obtain a comprehensive overview of changes in water composition resulting from the implementation of the integrated chicken–fish farming system.

The graph in Figure 2 shows substantial deterioration in water quality in the integrated pond compared to the raw water and control pond. The pH levels at all three locations remain within the normal range for aquaculture (6.5–8.0); however, the integrated pond shows a slightly higher pH. This increase may be attributed to microbial activity and the decomposition of organic waste, particularly the microbial degradation of proteinaceous materials derived from uneaten feed and poultry manure. Through hydrolysis, complex proteins are broken down into amino acids, which subsequently undergo microbial deamination to release free ammonia (NH_3) (Dey et al., 2021). In aquatic environments, ammonia partially dissociates into ammonium ions (NH_4^+) and hydroxide ions (OH^-), contributing to increased alkalinity and elevating the pond water pH (Młyńska et al., 2024; Kamila et al., 2024). In catfish aquaculture, maintaining a stable pH within this range is crucial, as extreme fluctuations can stress fish and disrupt metabolic processes.

A notable increase was observed in the TSS and TDS values, especially in the integrated pond. The elevated concentrations suggest an accumulation of solids, primarily from leftover feed and chicken manure. These solids not only reduce water clarity and habitat quality, but also correlate with microbial respiration, further stressing aquatic organisms, these solids can increase turbidity, reduce light penetration, and degrade the overall habitat quality for catfish (Nurhidayat, 2020). For optimal catfish growth, TSS should ideally remain below 25–100 mg/L, and TDS below 500 mg/L. Higher values may also interfere with gill function, cause stress, and promote pathogen proliferation in the water environment.

Nitrate, total phosphate, total nitrogen, and ammonia levels also increased sharply in the integrated pond, indicating nutrient pollution (eutrophication). This condition can trigger excessive algal growth and reduce dissolved oxygen levels (Hapsari et al., 2021). In the DO graph, a decline in oxygen concentration is evident in the integrated pond, posing a serious threat to fish survival (Dewa et al., 2022; Fuadi et al., 2020).

BOD and COD recorded the highest values in the integrated pond, reflecting a high load of organic matter due to biological activity and waste input (Młyńska et al., 2024) This condition is further worsened by a spike in fecal coliform levels, indicating microbial contamination from chicken excreta, which poses potential health risks (Opog et al., 2024).

Although individual water quality parameters exhibit considerable variation, the overall trend remains interconnected and mutually reinforcing in indicating pollution within the integrated chicken–fish farming pond system. Increased BOD and COD values reflect a high load of organic matter originating from leftover feed and chicken manure. This aligns with the spike in TSS and TDS, which signifies the accumulation of suspended particles and dissolved substances in the water.

The elevated levels of organic matter also result in high concentrations of nitrate, ammonia, total nitrogen, and phosphate, which are the end products of microbial decomposition of nitrogen and phosphorus compounds. This nutrient accumulation subsequently contributes to the decline in DO due to intensified microbial activity that consumes oxygen during the degradation process (Dewa et al., 2022).

In addition, the elevated fecal coliform count provides strong evidence of microbiological contamination caused by chicken excreta. Thus, although the numerical values of each parameter may vary, their directional changes form a logical and consistent pollution pattern, collectively reinforcing the degradation of water quality in this integrated aquaculture system. These findings are consistent with those of Kurniadi et al., (2024) and Melati et al., (2024) who stated that a simultaneous increase in organic matter and nutrients directly impacts the physical, chemical, and biological deterioration of aquatic environments, affecting the growth of cultured fish.

Overall, the graphs illustrate that ponds within the integrated chicken-fish system carry a higher pollutant load compared to control ponds and raw water. This highlights the urgent need for improved waste management to prevent broader environmental impacts.

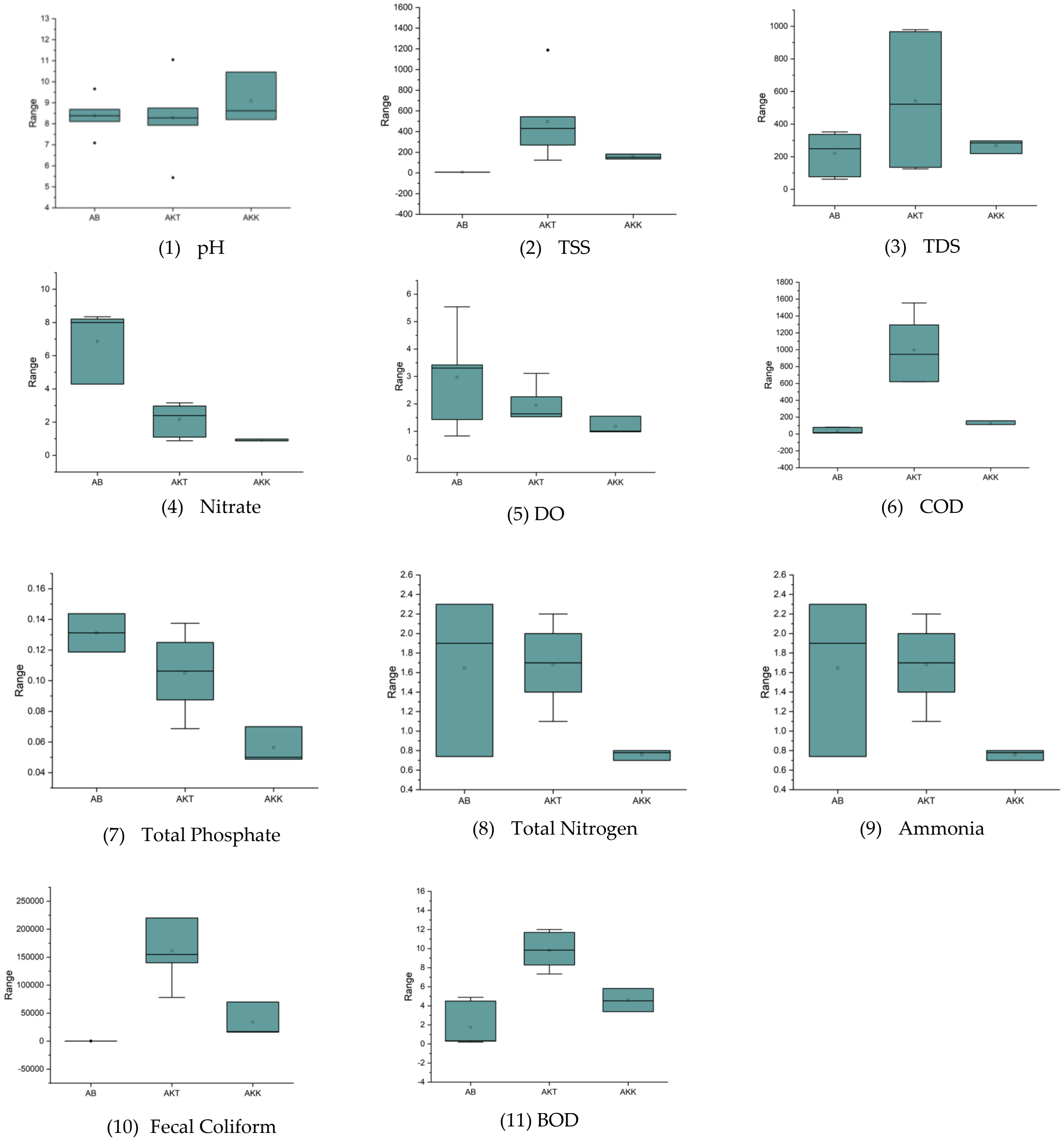

Figure 2. Comparison graph of 11 parameters among: AB = Raw Water, AKT = Integrated Pond Water, and AKK = Control Pond Water

3.3 Differences in Parameters and Their Impact on Water Quality

3.3.1 Raw Water Compared to Integrated Pond Water

An independent t-test was conducted to compare raw water and pond water in the integrated chicken-fish system, aiming to identify which water quality parameters differ significantly and are most affected by integrated farming activities. The analysis involved ranking the parameters based on their p-values, indicating the level of statistical significance for each observed difference.

Figure 3 demonstrates that the integrated chicken–fish farming system significantly increased BOD and COD levels ($p \leq 0.05$), indicating a substantial rise in pond water's biodegradable and refractory organic matter. Elevated BOD reflects microbial oxygen demand due to excess feed residues and fecal input, which aligns with findings by Adeyemi et al. (2022). Meanwhile, high COD values suggest the presence of persistent organic compounds—such as lipids or antibiotics from poultry waste—that are not readily degraded (Zhao et al., 2021). Although DO levels did not significantly decline, this rise in organic load poses a risk of oxygen depletion and ecosystem destabilization. Proper aeration and feed management are essential to mitigate hypoxia and sustain fish health (Ibrahim et al., 2021).

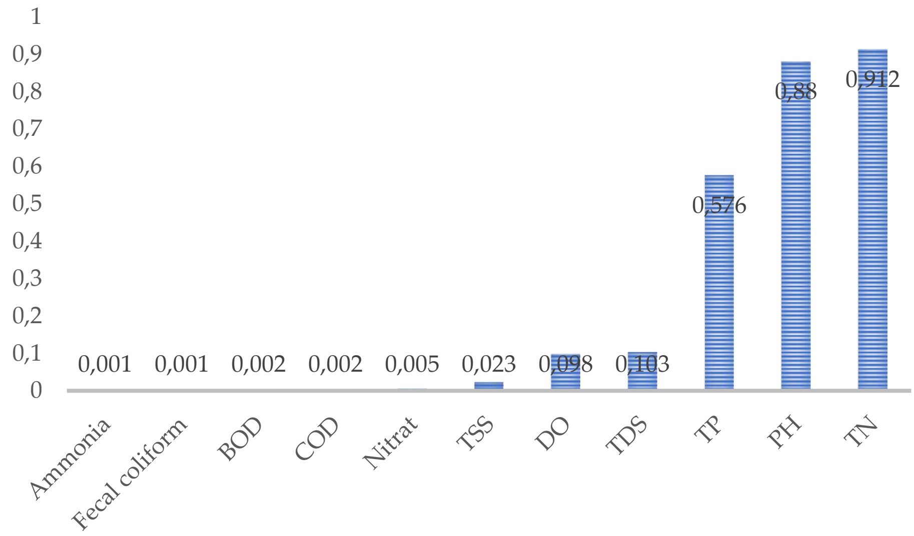

Figure 3. T-test results between raw water and integrated pond water

Significant ammonia elevation observed in the integrated pond water highlights the accumulation of nitrogenous waste from both fish and poultry metabolism. High levels of total ammonia nitrogen (TAN), especially above 1 mg/L, have been shown to impair fish gill function and reduce immune response (Qian et al., 2023). Without adequate microbial nitrification or water renewal, ammonia can reach toxic thresholds, increasing mortality risk. Therefore, implementing biological filtration, regulating stocking density, and adopting low-protein feed strategies are crucial for ammonia control and overall system resilience.

Nitrate concentrations were also significantly higher in the integrated pond water ($p \leq 0.05$), indicating an active nitrification process converting ammonia to less toxic nitrate. However, excessive nitrate (>10 mg/L) can lead to eutrophication, phytoplankton blooms, and oxygen crashes, as documented in fishponds receiving nutrient-rich inputs (Ngugi et al., 2022). Integrated systems without plant uptake mechanisms may suffer from nutrient imbalances. Introducing aquatic vegetation or implementing integrated multitrophic aquaculture (IMTA) can help absorb excess nitrate and phosphorus, thus maintaining ecological equilibrium and improving productivity (Rahman et al., 2023).

The sharp rise in fecal coliform counts reinforces microbial contamination from direct poultry waste discharge. FAO (2024) warns that coliform levels >1,000 MPN/100 mL threaten fish biosecurity and elevate public health risks if untreated effluents enter natural waterways. Adeyemi et al. (2022) identified multidrug-resistant bacteria in similar systems, raising concerns over antimicrobial resistance transmission. To mitigate these risks, pre-treatment of poultry manure (e.g., composting or anaerobic digestion) and routine microbial monitoring must be institutionalized. Sustainable integration demands nutrient recycling and strict pathogen control to safeguard aquaculture outputs and environmental health.

3.3.2 Raw Water Compared to Control Pond Water

The graph in Figure 4 presents the results of an independent two-sample t-test comparing raw water and control pond water (catfish cultivation without the integrated chicken-fish system). It displays the significance values (p-values) for each water quality parameter to determine whether there are statistically significant differences between water quality before and after being used for conventional catfish farming.

The t-test analysis demonstrated that Ammonia ($p = 0.023$), Fecal Coliform (FC) ($p = 0.030$), pH ($p = 0.015$), and Total Phosphate (TP) ($p = 0.042$) exhibited p-values ≤ 0.05, indicating statistically significant differences between raw water and integrated pond water. According to statistical convention, a p-value below 0.05 confirms that these differences are unlikely due to random variation, thus providing sufficient evidence of significant changes in water quality due to the integrated chicken-fish farming system. Elevated ammonia levels in pond water reflect nitrogenous waste accumulation from both chicken manure and fish excretion, potentially toxic at concentrations above 1 mg/L (Qian et al., 2023). Likewise, the significant rise in FC indicates fecal contamination from poultry waste, which poses a microbiological hazard to fish health and violates biosecurity thresholds (Adeyemi et al., 2022; FAO, 2024).

The significant decline in pH suggests increased microbial respiration and decomposition of organic matter, likely driven by the combination of fish metabolism and poultry droppings. Acidification reduces buffering capacity and influences ammonia toxicity, potentially shifting the balance toward more toxic un-ionized ammonia (Rahman et al., 2023). In parallel, the significant increase in TP levels indicates phosphorus loading from uneaten feed and feces, which can trigger eutrophication and algal bloom development in stagnant waters. These findings confirm that poultry integration leads to sharp alterations in pond water's chemical and microbiological quality, requiring robust nutrient and waste management strategies to mitigate environmental risks.

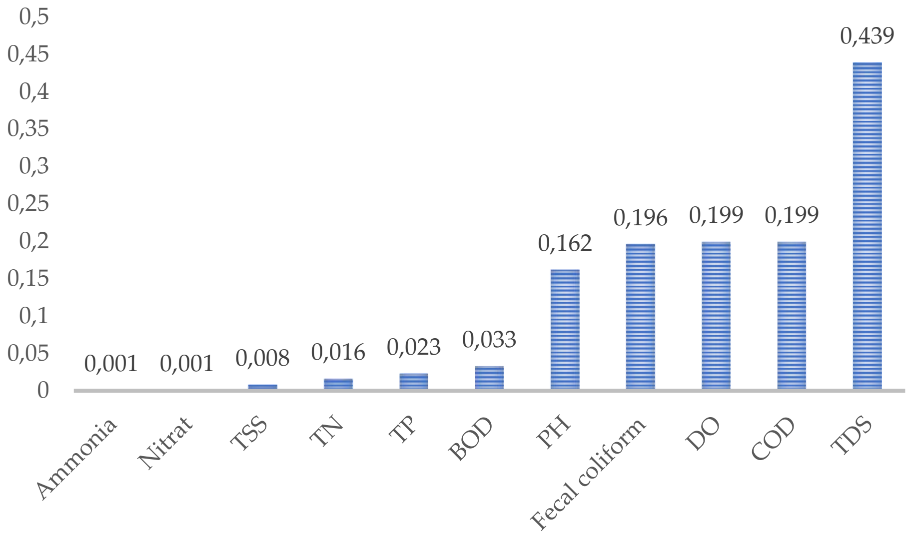

Figure 4. T-test results between raw water and control pond water

Conversely, other parameters such as BOD, Total Nitrogen (TN), Nitrate, COD, DO, and TDS had p-values > 0.05, indicating that observed differences were not statistically significant. This does not imply these parameters are unimportant, but rather that the magnitude of change was not strong enough to rule out the possibility of random variation. For instance, BOD and COD values suggest that while organic matter may have increased, the oxidative demand remained within manageable thresholds, possibly due to natural microbial activity. Similarly, DO stability may indicate adequate photosynthetic oxygenation, despite increased organic and nutrient loads (Ngugi et al., 2022).

Although TN and nitrate levels showed numerical increases, the lack of statistical significance may be due to dilution, sedimentation, or microbial uptake within the pond system. TDS levels remained relatively unchanged, suggesting minimal ionic concentration or salinity impact. Overall, the combination of statistically significant shifts in ammonia, FC, TP, and pH—alongside stable trends in other parameters—clearly indicates that integrated chicken-fish systems exert a targeted pressure on pond water quality, particularly through increased nutrient loading and microbial contamination. This underscores the need for waste separation, periodic water renewal, and biofiltration interventions.

3.4 Pollution Index (PI) Calculation

The water quality assessment at the three catfish farming sites within the integrated chicken–fish system in Blitar Regency was carried out using the Pollution Index (PI) method, per the Decree of Minister of Environment of The Republic of Indonesia Number 115 of 2003. This index quantifies water quality status by calculating the ratio between the measured concentration of each parameter and its respective quality standard, followed by averaging and classification. Based on the classification criteria, water quality status is categorized as follows: good (PI ≤ 1.0), lightly polluted (1.0 < PI ≤ 5.0), moderately polluted (5.0 < PI ≤ 10.0), and heavily polluted (PI > 10.0) (Decree of MoE Number 115 of 2003).

Figure 5 illustrates a stark contrast in Pollution Index (PI) values between raw and pond water across three study sites in Blitar Regency: Tegal Rejo, Talun, and Sawentar. In Tegal Rejo Village, the PI values for raw water were relatively low—6.64 and 7.62—falling into the "slightly polluted" category (PI < 10) according to the Nemerow classification. In contrast, the pond water exhibited severe water quality degradation, with PI values reaching 2200.39 and 2200.28 in Ponds 1 and 2, and 780.72 in Pond 3. These extremely high values fall under the "heavily polluted" category (PI > 10), with some exceeding a PI of 1000, which indicates critically degraded aquatic conditions.

A similar pattern was observed in Talun Village, where the raw water remained within the "slightly polluted" range (PI = 6.79 and 7.61). However, the pond water showed alarmingly high PI values of 1700.13, 1400.16, and 1400.16, confirming a "heavily polluted" status. Although these values were slightly lower than those in Tegal Rejo, the pollution trend remained substantial, suggesting that without proper waste management, integrated farming systems are highly susceptible to nutrient accumulation and microbiological contamination.

Sawentar Village initially exhibited the best raw water quality among the three sites, with PI values of 2.81 and 2.80, categorized as "good" to "very good." However, post-aquaculture activities led to a sharp rise in PI values in the pond water—1600.09 and 1700.09 for Ponds 1 and 2, and 700.23 for Pond 3. Despite the slightly lower PI in Pond 3, all values remained within the "heavily polluted" classification.

Overall, the PI assessment using the Nemerow classification approach (Sutadian et al., 2016) indicated that all raw water samples remained below the acceptable pollution threshold (PI < 10), In contrast, all pond water samples consistently exceeded the critical pollution limit (PI > 10), with many surpassing PI 1000. These findings reflect extremely high pollutant loads—particularly ammonia, phosphate, organic matter, and fecal contamination (Arviani et al., 2023; Al Baihaqi et al., 2020).

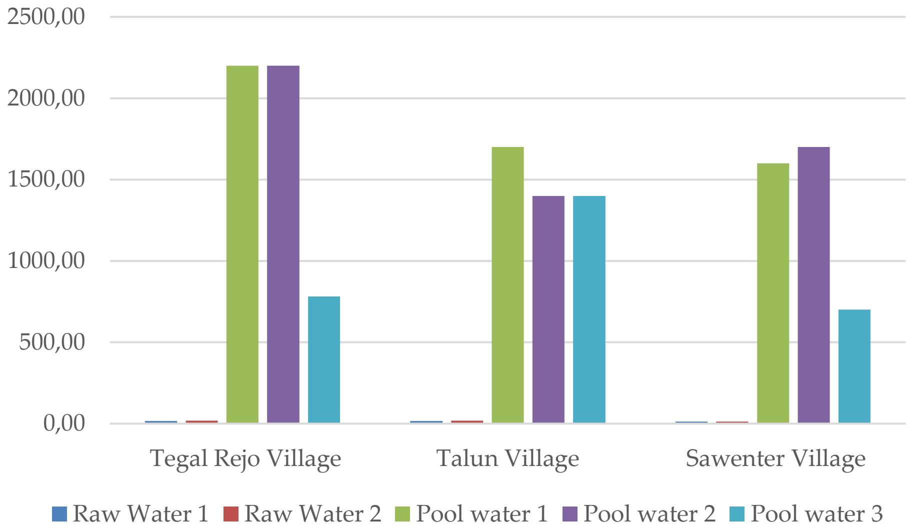

Figure 5. Pollution Index at the three catfish farming locations

This outcome aligns with previous studies demonstrating how integrated chicken–fish farming systems without appropriate waste treatment result in significant accumulation of pollutants (Adeyemi et al., 2022; Ngugi et al., 2022). Therefore, integrated waste management, including interventions such as poultry manure separation, enhanced aeration, biological filtration, and optimized stocking density, is crucial. These practices are essential for maintaining water quality within regulatory standards and ensuring the ecological sustainability and productivity of integrated aquaculture systems.

4. CONCLUSION

This study demonstrates that integrated chicken–fish farming systems can significantly degrade pond water quality due to unmanaged inputs of nutrients and organic waste, as evidenced by high concentrations of nitrogen, phosphate, BOD, COD, and elevated Pollution Index (PI) values. Without proper waste management, these systems pose serious environmental risks and threaten the sustainability of aquaculture operations. Practical interventions such as simple wastewater treatment units, routine sludge removal, biofiltration, and improved feeding practices are essential to restore ecological balance and reduce pollution.

Scientifically, this research fills a critical data gap on pollution dynamics in small-scale integrated aquaculture, particularly in tropical developing regions. It offers empirical evidence that can support future research and environmental modeling. Societally, the findings provide actionable insights for farmers, regulators, and policymakers to implement sustainable practices that promote both productivity and environmental protection, thereby bridging scientific knowledge with real-world application.

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REFERENCES

Adji, T. N., Cahyadi, A., Ramadhan, G. S., Haryono, E., Purnama, S., Tastian, N. F., Acitya, R., & Putra, R. D. (2023). Analisis dampak aktivitas antropogenik terhadap kualitas air sungai bawah tanah seropan, Kawasan Karst Gunungsewu, Kabupaten Gunungkidul. Jurnal Geografi, Edukasi Dan Lingkungan (JGEL), 7(1), 1–17.

Adeyemi, O., Nwodo, U., & Adeyemi, F. (2022). Assessment of microbial contamination and antimicrobial resistance in integrated fish–poultry aquaculture systems. Aquaculture Reports, 24, 101137.

Al Baihaqi, A., Sugianti, R., & Yulianti, D. (2020). Effects of organic waste accumulation on water quality and fish health in integrated aquaculture systems. Journal of Aquatic Systems, 12(3), 88–97

APHA, AWWA, WEF. (2023). Standard methods for the examination of water and wastewater (24th ed.). American Public Health Association, American Water Works Association, Water Environment Federation.

Arviani, R., Yusuf, M., & Sari, D. (2023). Ammonia accumulation and nutrient overloading in unmanaged aquaculture ponds. Aquatic Pollution Journal, 18(2), 103–112.

Dewa, I. G. T. Y., Nyoman, N. D. M., & Bagus, I. S. J. (2022). Studi perbandingan kualitas air dengan sistem resirkulasi yang berbeda pada parameter uji amonia, nitrit dan nitrate. Pendidikan Tambusai, 6, 12123–12130.

Dey, M., Asma A., Saiful I., Shaikat C. D., Tasrina R. C., Konica J. F., & Bilkis A. B. (2021). Assessment of contamination level, pollution risk and source apportionment of heavy metals in the Halda River water, Bangladesh. Heliyon, 7(12) 1-12.

DLHK DIY. (2023). Laporan Kinerja Instansi Pemerintah 2022.

FAO. (2024). Biosecurity and pathogen risk in integrated aquaculture systems. Aquaculture Technical Guidelines Series No. 18.

Fuadi, A., & Sami, M. (2020). Teknologi tepat guna budidaya ikan lele dalam kolam terpal metode bioflok dilengakapi aerasi nano buble oksigen. Jurnal Hasil-Hasil Penerapan IPTEK, 4(1), 39–45.

Hapsari, L. P., Suryana, A., Nurhudah, M., Wahyudi, D., & Ramli, T. H. (2021). Evaluation of the value of ammonia, nitrate, and nitrite on cultivation media of catfish fed maggot. Jurnal Rekayasa dan Teknologi Budidaya Perairan X, 15–22.

Ibrahim, R., Noor, S., & Zakaria, Z. (2021). Influence of organic waste on dissolved oxygen and fish health in semi-intensive aquaculture ponds. Environmental Monitoring and Assessment, 193(6), 354.

Kamila, A., Sadidan, I., & Fauzie, A. K. (2024). Penilaian status mutu air sungai citarum menggunakan metode indeks pencemaran. Ruwa Jurai: Jurnal Kesehatan Lingkungan, 18(2), 84–91.

Kurniadi, B., Rahayu, S., & Munir, A. M. S. (2024). Manajemen kualitas air pada pembesaran ikan di Desa Sambora Kecamatan Toho Kabupaten Mempawah. Jurnal Abdimas Ilmiah Citra Bakti, 5(3), 605–613.

Melati, A., Eddy S., Yuni P.H., & Kukuh N. (2024). Status kualitas air untuk penilaian lingkungan sekitar tambak ekstensif di Balikpapan, Kalimantan Timur. Jurnal Sains Akuakultur Trop, 1, 116–128.

Młyńska, A., Halecki, W., & Chmielowski, K. (2024). Efficient biological treatment: Achieving exceptional reductions in pollutants and ensuring environmental compliance. Desalination and Water Treatment, *319*, 1–9.

Nurhidayat, R. (2020). Pengendalian kualitas air pada budidaya ikan lele jenis mutiara. Jurnal Ilmiah Mahasiswa Kendali dan Listrik, 1(2), 42–50.

Nurlaili R & Ulfa B.A. (2019). Penentuan lokasi sentra produksi komuditas telur ayam ras di Kabupaten Blitar. Jurnal Tenik ITS, 2, 207–212.

Ngugi, C. C., Muendo, P. N., & Ochieng, J. O. (2022). Eutrophication risks in fishponds receiving agricultural runoff. Environmental Science and Pollution Research, 29, 44103–44112.

Opog, L. M., Casila, J. C., Lampayan, R., Sobremisana, M., Bulasag, A., Yokoyama, K., & Haddout, S. (2024). Assessment of chicken fecal contamination using Microbial Source Tracking (MST) and Environmental DNA (eDNA) Profiling in Silway River, Philippines. Journal of Xenobiotics, 14(4), 1941–1961.

Puspitasari, P., Permanasari, A. A., Sukarni, S., Taufiq, A., & Susilo, G. D. (2022). Implementasi teknologi nano microbubble aerator pada kolam lele untuk meningkatkan kadar oksigen air dan mempercepat pertumbuhan benih ikan lele. JP2T, 3(1), 14–20.

Rahman, M. M., Akter, T., & Khan, M. H. (2023). Role of aquatic plants in nitrate removal from aquaculture wastewater. Aquatic Ecosystem Health & Management, 26(1), 49–58.

Saifullah, U. J. (2021). Budidaya ikan nila dengan sistem probiotik di Desa Simpang Empat Kecamatan Tangaran. Dipamas, 3(1), 9–5.

Srirahayu, D., & Adi, I. R. (2021). Pengembangan ekonomi lokal dan peran konektivitas global lokal dalam peningkatan wawasan peternak ayam layer di Kabupaten Blitar. Jurnal Kajian Wilayah, 12(1), 61–82.

Suada, I. K., & Tenaya, I. W. M. (2023). Analisis limbah sapi yang berpotensi mencemari lingkungan dan menularkan penyakit pada masyarakat. Buletin Veteriner Udayana, 15, 1012–1022.

Yakin, E. A., Wahyu Mulyono, A. M., Sariri, A. K., & Sukaryani, S. (2020). Aplikasi teknologi budidaya mina ayam di Desa Selorejo Girimarto Wonogiri. Jurnal Pengabdian Kepada Masyarakat, 3(2), 336–347.

Zaidy, A. B. (2022). Pengaruh pergantian air terhadap kualitas air dan performa produksi ikan lele dumbo (*Clarias gariepenus*) dipelihara di kolam bioflok. Jurnal Penyuluhan Perikanan Dan Kelautan, 16(1), 95–107.