

# Physicochemical and microbiological assessment of oyster farms in Ilocos Sur, Philippines



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**Abstract** Oyster farming in the Philippines plays a crucial role in the livelihoods of local communities, particularly in rural coastal areas of Ilocos Sur. However, the industry faces environmental degradation, limited market demand, and a prolonged cultivation period, which hinder its profitability and sustainability. This study evaluated the physicochemical and microbiological quality of water in six selected oyster farms using standardized analytical techniques. Surface water samples were collected and analyzed for temperature, pH, turbidity, total coliforms, and fecal coliforms. Physicochemical parameters were measured using the SPARK Science Learning System, while microbial quality was assessed through multiple tube fermentation technique. Results indicate that the temperature range from 28.1 to 30.1°C and pH levels of 7.56 to 7.79 obtained from all farms are within the DENR standards and suitable for oyster culture. However, turbidity in most farms exceeded the permissible level of 5 NTU, which is dangerous for oyster health. More importantly, many of these farms' fecal and total coliform counts are alarming, far higher than the DENR standard of 70 MPN/100 mL. The conditions are generally suitable for oyster farming. However, special attention is required concerning water turbidity and microbial contamination. These factors have related implications for such farms' sustainability and the harvested oysters' safety. Regular water quality monitoring, farm management improvement practices, community education for environmental protection measures, and strict enforcement of regulation measures against potential contamination risks are recommended.

**Keywords:** oyster farming, water quality, sustainable aquaculture, physicochemical analysis, microbial contamination

## 1. Introduction

Global aquaculture production has seen unprecedented growth over the past five decades, supplying over half of the world's fish food (FAO, 2018). Among farmed aquatic species, mollusks, particularly oysters, constitute the second-largest group by volume and value. Oysters are especially dominant in Asia, which accounts for 95% of global production by weight. The Philippines, with a history of oyster farming since the early 1900s (Rabanal, 2000), continues to integrate oyster cultivation into the livelihoods of many coastal communities.

In Ilocos Region, aquaculture posted a production of 27,449 metric tons in the first quarter of 2021, of which Ilocos Sur contributed 0.59% (Philippine Statistics Authority, 2021). While modest in scale, oyster farming in the province, especially in municipalities like Magsingal, San Vicente, Caoayan, Narvacan, Candon, and Sta. Maria serves as a vital income source for marginalized fisherfolk (Domingo et al., 2021; Rodolfo & Lapus, 2021). These communities depend on estuarine ecosystems where shellfish, including oysters, provide accessible nutrition and commercial value due to their high-quality protein, essential micronutrients, and long-chain polyunsaturated fatty acids (Venugopal & Gopakumar, 2017).

Despite its socioeconomic value, oyster aquaculture in Ilocos Sur faces challenges such as prolonged cultivation periods, market constraints, and, most critically, poor water quality. Local farms are typically situated in shallow estuaries vulnerable to contamination from agricultural runoff, sewage, and domestic effluents, all of which impact water clarity, microbial load, and overall oyster health (Bhaja & Kundu, 2012; Guerrero, 2006). The physicochemical and microbial integrity of water parameters such as turbidity, pH, temperature, and coliform levels has direct implications for the growth, survival, and safety of oysters (Ilac, 2024; Jearmsripong et al., 2022).

Previous reports have flagged public health concerns due to microbial contamination of oysters in areas influenced by human activities (Andalecio et al., 2014). Risk factors include pathogenic bacteria, parasites, and heavy metals, as well as bioaccumulative toxins. Other issues, such as inefficient management practices, lack of fingerlings, and erratic environmental conditions, have also contributed to production shortfalls (Silva et al., 2021).

Despite the longevity and geographic reach of oyster aquaculture, rigorous assessments of the factors affecting oyster aquaculture productivity and markets are limited, which may limit the potential to determine future oyster production. To date, no study has been conducted that reveals the water quality of the different oyster farms in Ilocos Sur. Hence, this research



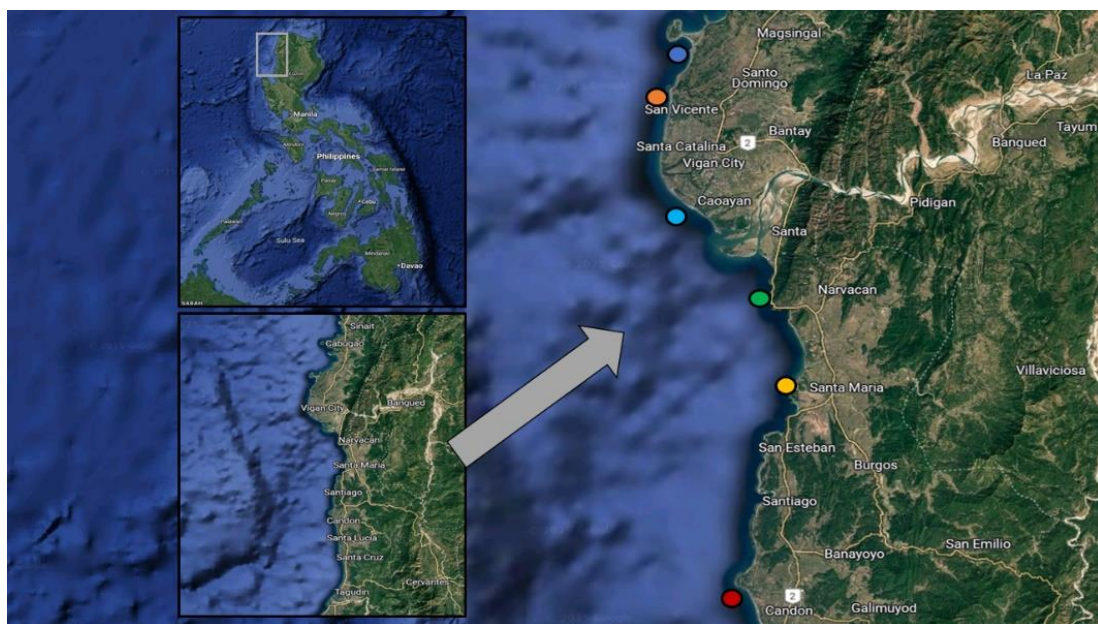
should mend the knowledge gap to explore the issues about the water quality of oyster farms and thereby develop preventive measures if necessary. The data that will be garnered will be used as baseline information to establish the environmental quality of these farms and the oysters being harvested, and it will contribute to policy-making that will safeguard food security, safety, and public health in the province.

## 2. Materials and Methods

This research employed a qualitative descriptive design, supported by empirical laboratory analyses to examine the water quality of six oyster farms located in Magsingal, San Vicente, Caoayan, Narvacan, Candon, and Sta. Maria, Ilocos Sur. Each site was selected based on its contribution to regional oyster production and proximity to potential contamination sources such as residential settlements or river outlets.

### 2.1. Collection of Water Samples from Selected Oyster Farms

Water samples were collected in six (6) oyster farms from the Municipality of Magsingal, San Vicente, Caoayan, Narvacan, Candon, and Sta. Maria, Ilocos Sur, Philippines (Figure 1). From each location, three replicate surface water samples were collected at a depth of 30–50 cm during a single sampling event in the dry season to minimize seasonal variability. The use of single-time sampling was chosen due to logistical constraints; however, it offers a snapshot of water quality under relatively stable conditions, a common approach in preliminary ecological assessments (Lee et al., 2018). The water samples were placed in sterilized bottles and labeled to indicate the date of collection, time of collection, and location. To account for variability, any aberrant results were flagged and supported by field notes. Additionally, while the study did not monitor environmental covariates in real-time, background data on rainfall, salinity, and land use near the sites were recorded to contextualize microbial variations, as these are known to influence coliform dynamics in estuarine waters (Jeamsripong et al., 2022).



**Figure 1** Selected oyster farms in Ilocos Sur.

Following the standard procedure by the DENR-EMB (2008), all sampling bottles used in the study were clear, wide-mouth, and glass made that can contain 200 ml liquid with a heat-resistant plastic screw cap. Before the collection schedule, all sampling bottles were prepared and cleansed with liquid detergent and tap water and then rinsed with distilled water. A thin aluminum foil cover was used to protect both the cover and neck of the bottles from contamination, and they were sterilized by autoclaving at 121°C.

Each collection bottle was grasped by hand near the base and arm on the downstream side of the bottle and plunged below the water surface to a depth of approximately 30-50 cm. The opening of the sterile bottle was pointed slightly upward into the water, and a one hundred fifty (150) ml sample of water was collected to fill the bottle. After filling, the bottles were removed with the opening pointed upward toward the water surface. The collection bottles were tightly capped, allowing about 2.5 to 5 cm of head space to accommodate proper mixing. After collection, the surface water samples were stored in an icebox with a temperature maintained at 4°C-8°C, and they were transported immediately to the Microbiology and Biotechnology Laboratory, Science Complex of the University of Northern Philippines. The samples were processed within 4-6 hours of being collected.

## 2.2. Physicochemical and Microbiological Analysis

The physicochemical properties of the water samples were analyzed using the SPARK Science Learning System, which was based on the following parameters: temperature, pH, and turbidity. The SPARK Science Learning System was calibrated prior to each measurement session using manufacturer-provided buffer standards and turbidity calibration solutions. Calibration logs and sensor drift checks were maintained as part of quality assurance, following established environmental monitoring protocols.

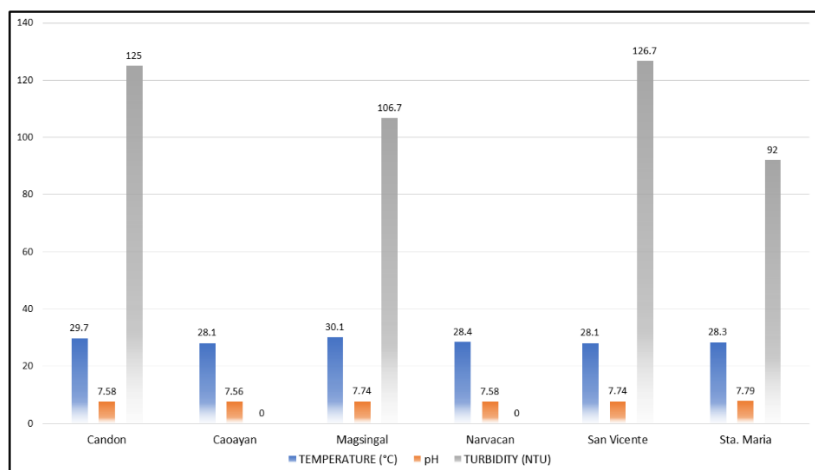
Microbiological assessment utilized the Multiple Tube Fermentation Technique (MTFT) to estimate total and fecal coliforms using MPN statistics following the standards recommended by DENR-EMB. The technique utilized a two-step incubation procedure. During the presumptive test, five Durham fermentation tubes with 20 mL lactose broth were aseptically inoculated with 10 mL properly mixed surface water sample for the first dilution. Ten (10) ml of lactose broth was used in the subsequent dilution, and a 1 ml sample of mixed surface water was added for the second dilution. One (1) ml of the mixed surface water sample was diluted to 9 ml of sterile distilled water to obtain a 0.1 ml dilution and added to a 10 ml lactose broth. Turbid surface water samples were further diluted by 1 ml of 0.1 ml dilution, and 9 ml of sterile distilled water was added to the water sample. After diluting turbid surface water samples, 1 ml of the diluted sample was aseptically inoculated into a sterile screwcap tube containing 10 ml of lactose broth. The tubes were incubated at 35 °C for 24 hours. Negative test tubes were further incubated to complete 48 hours of incubation. All positive tests (with gas formation) after 24 hours or 48 hours of incubation were inoculated (0.03 mL) to brilliant green lactose bile (BGLB) broth and *Escherichia coli* (E.C.) broth. All BGLB broths were incubated at 35 °C for 24 to 48 hours, while all E.C. broths were at 44.5 °C. Positive samples were used to determine the most probable number (MPN) of the total and fecal coliforms using standard MPN tables (Pagaoa et al., 2024). Additionally, while the study did not monitor environmental covariates in real-time, background data on rainfall, salinity, and land use near the sites were recorded to contextualize microbial variations, as these are known to influence coliform dynamics in estuarine waters (Jeamsripong et al., 2022).

## 3. Results

Water quality parameters, including temperature, pH, and turbidity, are vital in assessing the suitability of aquatic environments for oyster cultivation. These factors influence oyster development, survival, and overall health while also shaping the microbial balance of the water, which can have significant implications for food safety and public health. This study analyzed the water samples from six oyster farms across Ilocos Sur, Philippines.

### 3.1. Physicochemical characteristics of the oyster farms

The physicochemical analysis result is presented in Figure 2. It shows that the temperature of water samples from selected oyster farms in Ilocos Sur ranges from 28°C to 30°C, which is within the DENR temperature guidelines of 26 to 30 °C. Magsingal had the highest recorded temperature among the selected oyster farms at 30.1°C, while Caoayan and San Vicente had the lowest temperature at 28.1 °C. The pH level of water samples from the oyster farms in Ilocos Sur ranges from 7.56 to 7.79, which is within the DENR standard for pH levels 7-8.5. Water samples from Sta. Maria got the highest pH level, 7.79, whereas Caoayan, Ilocos Sur got the lowest pH level among the six water samples, 7.56. The turbidity of water samples from the selected oyster farms in Ilocos Sur was beyond the DENR standard, which is 5 NTU. Results show that the turbidity level of water samples is high in Candon, Magsingal, and Sta. Maria and San Vicente, with 125, 106.7, 126.7, and 92, respectively. On the other hand, Caoayan and Narvacan have a turbidity of 0 NTU.

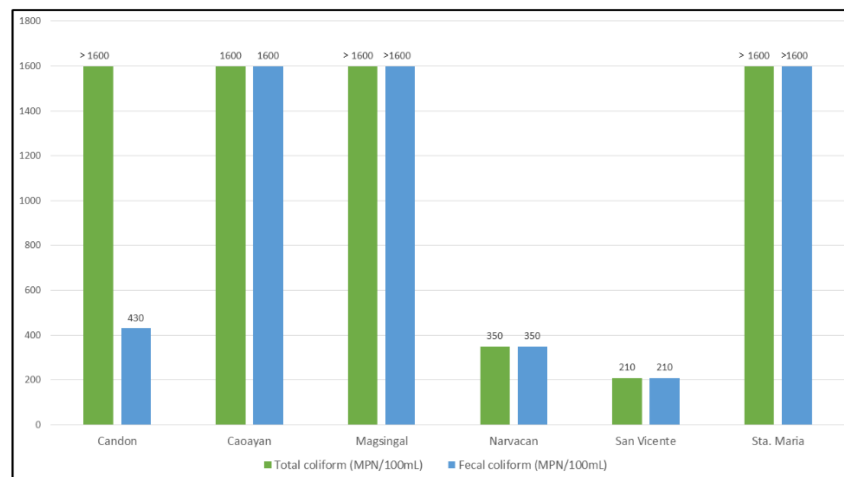


**Figure 2** Physicochemical characteristics of water samples from the selected oyster farms in Ilocos Sur, Philippines.

### 3.2. Microbiological quality of the oyster farms

Microbiological analysis of water samples from oyster farms provides crucial insights into water quality and safety. The result is presented in Figure 3. The result revealed widespread and significant contamination, as both total coliform and fecal coliform counts exceeded the permissible limit of 70 MPN/100 mL set by the Department of Environment and Natural Resources (DENR) for Class SC waters. The most heavily contaminated sites were Candon, Caoayan, Magsingal, and Sta. Maria, all of which showed total coliform levels exceeding 1600 MPN/100 mL which is the upper detection threshold of the employed method. These same locations also reported critically high fecal coliform levels, with Caoayan, Magsingal, and Sta. Maria each recording more than 1600 MPN/100 mL, suggesting a high load of fecal contamination.

In contrast, the microbial loads in Narvacan and San Vicente were considerably lower, with total and fecal coliform counts of 350 MPN/100 mL and 210 MPN/100 mL, respectively. Interestingly, the equal values of total and fecal coliforms in Narvacan (350 MPN/100 mL) and San Vicente (210 MPN/100 mL) were observed. Meanwhile, Candon exhibited a unique pattern with total coliforms exceeding 1600 MPN/100 mL, but a notably lower fecal coliform count of 430 MPN/100 mL.



**Figure 3** Microbiological quality of water samples collected from selected oyster farms in Ilocos Sur, Philippines.

## 4. Discussion

The observed water temperature in all farms supports oyster development, as oysters thrive within 16–30 °C. This range stimulates metabolic activity and growth in many oyster species, including Sydney rock oysters (Dove & O'Connor, 2007) and European oysters (Robert et al., 2017). However, while warmer temperatures may promote growth, they also increase susceptibility to stress and disease (Rahman & Rahman, 2020). In the Philippines, the optimal temperature for larval growth in *Magallana bilineata* lies between 24–29 °C (Sudradjat, 2006), making the observed values acceptable but bordering the upper thermal tolerance for some species. The pH levels remained within acceptable bounds, suggesting low risk for pH-induced physiological stress. Nonetheless, studies show that even moderate acidification (pH 7.5) can reduce reproductive viability in *Crassostrea gigas* and delay larval settlement, especially when combined with other stressors such as reduced salinity or high temperatures (Ko et al., 2014; Omoregie et al., 2019). The high turbidity levels in Sta. Maria, Magsingal, and Candon are concerning. Oysters are filter feeders, and excessive suspended particles can impair feeding efficiency, reduce oxygen availability, and lead to physiological stress (Campbell, 2022). Additionally, high turbidity alters trophic interactions, such as increasing predator abundance (Lunt & Smee, 2014). The recorded turbidity levels in Caoayan and Narvacan were 0 NTU, indicating exceptionally clear water conditions at the time of sampling.

Microbiological contamination in all sites exceeded safe limits, aligning with previous studies reporting coliform and *E. coli* presence in oyster aquaculture zones (Pakingking et al., 2021; Pereira, 2006). The high coliform levels likely stem from land-based pollution, including untreated sewage and agricultural runoff. These findings highlight the risks of pathogen exposure, particularly in tropical estuarine environments, where seasonal factors (e.g., rainfall) further exacerbate microbial proliferation (Silva et al., 2020; Neta et al., 2015). Although oysters have shown capabilities for bacterial depuration, especially against *E. coli*, viral contamination (e.g., norovirus) remains a concern (Rodrigues et al., 2023). Preventive measures must prioritize upstream waste management and regular microbial monitoring to safeguard both environmental health and public food safety.

## 5. Conclusions

The findings from this study reveal that while temperature and pH conditions in the oyster farms are within acceptable limits, the high turbidity and coliform contamination pose significant risks to both oyster health and consumer safety. The high microbial load threatens the sustainability of oyster farming in the region and calls for stringent water quality management

practices. Regular monitoring and enforcement of environmental regulations are crucial to mitigate contamination risks and ensure the continued viability of oyster farming in Ilocos Sur.

Based on the results, it is recommended that oyster farmers and local authorities implement regular water quality assessments to monitor and control turbidity and microbial contamination. There is also a need for improved waste management practices in nearby communities to reduce runoff and sewage discharge into water bodies. Additionally, community education on environmental protection can play a vital role in safeguarding the water quality, thus ensuring the sustainability of the oyster farming industry in Ilocos Sur.

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### Ethical considerations

Not Applicable.

### Conflict of Interest

The authors declare no conflicts of interest.

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