Research Article
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# Study of Mineral Content in Pond Water for Traditional Farming of Black Tiger Shrimp (*Penaeus monodon*) in Tarakan City

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**Abstract:** Although required only in trace amounts, minerals are vital for the cultivation of black tiger shrimp (*Penaeus monodon*). However, limited studies have explored the link between mineral availability and shrimp farming performance. This study aimed to identify the types and concentrations of minerals present in shrimp ponds located in two different areas of Tarakan City, North Kalimantan, namely West Tarakan and East Tarakan districts. An exploratory approach was employed, and samples were collected using purposive sampling techniques. The analysis revealed that concentrations of Magnesium (Mg), Calcium (Ca), and Iron (Fe) in both ponds met the quality standards suitable for shrimp farming. In Pond 1, Mg levels ranged from 1200 to 1245 mg/L, Ca from 438 to 480 mg/L, and Fe was below 0.02 mg/L. Similarly, in Pond 2, Mg levels ranged from 1200 to 1290 mg/L, Ca from 432 to 480 mg/L, and Fe remained below 0.02 mg/L. These values indicate that the presence of these minerals poses no toxicity risk to shrimp culture environments. Furthermore, water quality parameters such as temperature, salinity, pH, and dissolved oxygen were within the acceptable range for P. monodon cultivation. No significant correlation was found between water quality and mineral concentrations. Harvest results showed a yield of 90 kg (average size 35) with a 90% survival rate in Pond 1, from an initial stocking of 3,000 post-larvae. In contrast, no shrimp were harvested from Pond 2, and the absence of yield was attributed to suspected predation, as no disease outbreak or mass mortality was observed. These findings highlight the importance of stable mineral conditions in supporting successful shrimp farming, and suggest further investigation into non-water quality factors such as predation.

## Introduction

Tarakan City spans an area of 657.33 km², of which 61.8% or approximately 406.53 km² consists of marine waters, offering substantial potential for the development of marine and fisheries sectors (1). In addition to its marine territory, Tarakan also supports traditional aquaculture practices, particularly black tiger shrimp (Penaeus monodon) farming, through coastal pond systems, with production increasing by 175% from 2018 to 2022 (2). Pond-based aquaculture utilizes coastal areas to rear aquatic organisms within artificially or naturally formed enclosures, typically ranging from 1 to 2 hectares in size (3). These systems may be seasonal or permanent and play a dual role by supporting the aquatic ecosystem while contributing significantly to coastal community incomes, employment opportunities, and national economic growth (4).

The success of pond aquaculture is strongly influenced by environmental factors, especially water quality, which is considered a critical determinant for sustainable operations (5-7). Inadequate water conditions can lead to outbreaks of pests and diseases, which are commonly linked to environmental stressors. Water quality varies between ponds due to differences in site characteristics and surrounding influences, such as agricultural runoff, residential areas, mangrove coverage, and estuarine proximity. Among the key water quality parameters, minerals although required in small amounts play a crucial role (8, 9).

Minerals are essential for crustaceans like shrimp, contributing to basal metabolism, growth, and immune function. In addition to dietary sources, shrimp actively absorb minerals from the surrounding water (10). Adequate mineral availability in pond water has been shown to improve shrimp survival rates and growth performance. Balanced mineral ratios, such as sodium to potassium (Na/K) and magnesium to calcium (Mg/Ca), also positively affect shrimp development (11). Furthermore, minerals are vital during larval stages, molting processes, and biomass accumulation, as well as in enhancing immune responses. Despite their importance, data on water quality and mineral content in aquaculture ponds, especially in North Kalimantan, remain scarce. This study aims to assess essential mineral availability in shrimp ponds and examine their potential relationship with cultivation success (12).

# Methodology

## Time and Location of the Study

This research was conducted from April to July 2022, with sample collection carried out at traditional black tiger shrimp (*Penaeus monodon*) aquaculture ponds located in Tarakan City, North Kalimantan Province. Laboratory analysis of the samples was performed at the Nutrition Laboratory, 2nd Floor, Faculty of Fisheries and Marine Sciences, Borneo Tarakan University. The study site consisted of an extensive aquaculture pond system, managed with minimal human intervention and reliant on natural environmental conditions, without artificial aeration or supplemental feed, and featuring a single water inlet (13)The pond spanned an area of approximately 7 hectares, with post-larvae (PL) shrimp stocked at densities ranging from 4 to 70 individuals per square meter. At the time of the study, the shrimp had been stocked at the PL-20 stage and had reached 16 days post-stocking(14). The study included two pond locations categorized by their proximity to environmental influences: K1 (located less than 500 meters from an agricultural area) and K2 (located less than 500 meters from a residential area). For comprehensive sampling, each pond was sampled at three distinct points: the inlet gate, the left side, and the right side of the pond.

## Materials and Equipment

The equipment utilized in this study included sample bottles, a pH meter, a dissolved oxygen (DO) meter, a thermometer, a volumetric pipette, and a refractometer. The materials used comprised pond water samples, distilled water (aquadest), and a test kit for water quality analysis.

## Research Procedure

The research procedure involved several key stages, including site selection of the shrimp ponds, determination of sampling points, sample testing, data collection, and data analysis.

## Sampling Method

Pond water samples were collected over a three-month period, starting from the stocking phase up to the harvest stage. Sampling was carried out twice per month, with triplicate samples taken during each session to improve data reliability. All water samples were placed in sterile containers and stored in a refrigerator to preserve their integrity before being transported to the laboratory for analysis. Sampling was conducted with a clear layout of points to ensure representativeness, as explained below.

## Sample Collection

The sampling method employed in this study was purposive sampling, a technique based on deliberate selection in which samples are chosen to represent the pond area effectively. Sampling points were divided into three locations according to pond size: point 1 at the inlet gate, point 2 on the left side of the pond, and point 3 on the right side. After collection, water samples were stored in an ice box to preserve their quality prior to laboratory analysis.

## Sample Analysis

The samples stored in the refrigerator were subsequently transported to the laboratory at Borneo Tarakan University for further analysis. The tests conducted included measurements of mineral content, specifically magnesium, calcium, and iron. Each was tested using a water quality test kit to determine its concentration.

## Data Collection

Data collection in this study was carried out through direct field observations and water sample collection, which were later analyzed in the Laboratory of the Faculty of Fisheries and Marine Sciences, Borneo Tarakan University. The parameters measured in situ at the research site, based on the method proposed by Sustianti *et al*. (2014), included water temperature measured with a thermometer, salinity using a refractometer, water pH with pH paper, and dissolved oxygen (DO) using a DO meter (15).

## Data Analysis

The data analysis was conducted descriptively and comparatively by comparing the concentrations of minerals (Mg, Ca, Fe) and water quality parameters (temperature, pH, salinity, and dissolved oxygen) to established suitability standards for black tiger shrimp farming. Additionally, patterns between water quality parameters and mineral concentrations were examined descriptively across time points. Since no formal statistical tests were performed, statements such as “no significant correlation” are based on visual trend interpretation, not on inferential statistics.

To improve data reliability, each water sampling session was conducted in triplicate. These replicates helped reduce the impact of outliers and measurement error, allowing for a more accurate estimation of average values.

# Results

This study was conducted in Tarakan City, North Kalimantan, to analyze the mineral content in traditional black tiger shrimp (*Penaeus monodon*) ponds. The study took place in two locations: Pond 1 in West Tarakan and Pond 2 in East Tarakan. Sampling was performed at three distinct points per pond (inlet, left embankment, right embankment), and results were assessed based on Indonesian water quality standards (SNI 06-2412-1991 and PP No. 22 of 2021). The results of the mineral content analysis (magnesium, calcium, iron) can be found in **Table 1**.

**Table 1** shows mineral concentrations in Pond 1, which remained relatively stable over the eight-week period. Instead of repeating exact values, the focus here is on observed trends. Magnesium and calcium levels exhibited slight fluctuations but stayed within safe and recommended ranges. Iron was consistently undetectable, indicating minimal risk of toxicity. These patterns suggest that the pond environment maintained stable mineral availability suitable for shrimp cultivation.

In Pond 2, mineral concentrations varied more than in Pond 1, especially for magnesium (see **Table 2**). A noticeable increase was observed in week 6, followed by a decline toward week 10. However, these fluctuations still remained within tolerable ranges. Calcium levels showed mild inconsistency, while iron was again consistently below detection limits. Pond 2 yielded no harvest, even though both mineral and water quality parameters were within acceptable ranges. The pond owner suspected early-stage

**Table 1.** Mineral concentrations during the grow-out period of Penaeus monodon in Pond 1.

| Week | Parameter | TS1 (mg/L) | TS2 (mg/L) | TS3 (mg/L) | Average (mg/L) |
|---|---|---|---|---|---|
| 0 | Mg | 1230 | 1200 | 1215 | 1215 ± 15 |
| | Ca | 450 | 456 | 450 | 452 ± 3.5 |
| | Fe | <0.02 | <0.02 | <0.2 | <0.02 |
| 2 | Mg | 1200 | 1215 | 1230 | 1215 ± 15 |
| | Ca | 444 | 450 | 438 | 444 ± 6 |
| | Fe | <0.02 | <0.02 | <0.02 | <0.02 |
| 4 | Mg | 1200 | 1215 | 1245 | 1220 ± 22.9 |
| | Ca | 474 | 474 | 480 | 476 ± 3.5 |
| | Fe | <0.02 | <0.02 | <0.02 | <0.02 |
| 6 | Mg | 1200 | 1245 | 1215 | 1220 ± 22.9 |
| | Ca | 462 | 480 | 480 | 474 ± 10.4 |
| | Fe | <0.02 | <0.02 | <0.02 | <0.02 |
| 8 | Mg | 1230 | 1230 | 1215 | 1225 ± 8.7 |
| | Ca | 444 | 444 | 438 | 442 ± 3.5 |
| | Fe | <0.02 | <0.02 | <0.02 | <0.02 |

**Description:** TS1 = Water inlet gate. TS2 = Left side of the embankment. TS3 = Right side of the embankment.

**Table 2.** Mineral concentrations during the grow-out period of Penaeus monodon in Pond 2.

| Week | Parameter | TS1 (mg/L) | TS2 (mg/L) | TS3 (mg/L) | Average (mg/L) |
|---|---|---|---|---|---|
| 0 | Mg | 1215 | 1200 | 1230 | 1215 ± 15 |
| | Ca | 396 | 480 | 456 | 444 ± 43.2 |
| | Fe | <0.02 | <0.02 | <0.2 | <0.02 |
| 2 | Mg | 1215 | 1200 | 1215 | 1210 ± 8.6 |
| | Ca | 438 | 450 | 432 | 440 ± 9.1 |
| | Fe | <0.02 | <0.02 | <0.02 | <0.02 |
| 4 | Mg | 1200 | 1200 | 1200 | 1220 ± 0.00 |
| | Ca | 420 | 450 | 436 | 436 ± 15 |
| | Fe | <0.02 | <0.02 | <0.02 | <0.02 |
| 6 | Mg | 1275 | 1290 | 1290 | 1285 ± 8.6 |
| | Ca | 474 | 480 | 480 | 478 ± 10 |
| | Fe | <0.02 | <0.02 | <0.02 | <0.02 |
| 8 | Mg | 1245 | 1230 | 1200 | 1225 ± 22.9 |
| | Ca | 430 | 444 | 450 | 439 ± 10 |
| | Fe | <0.02 | <0.02 | <0.02 | <0.02 |
| 10 | Mg | 1215 | 1200 | 1215 | 1210 |
| | Ca | 480 | 450 | 438 | 456 ± 21.6 |
| | Fe | <0.02 | <0.02 | <0.02 | <0.02 |

**Description:** TS1 = Water inlet gate. TS2 = Left side of the embankment. TS3 = Right side of the embankment.

predation as the main cause, since no mass mortality or disease outbreak was observed during the study. In contrast, Pond 1 yielded a successful shrimp harvest of 90 kg (size 35), with a survival rate of 90% from 3,000 stocked individuals. The consistent mineral profile in Pond 1, combined with good water quality, may have contributed to optimal growth and low mortality during the grow-out period. These interpretations are based on descriptive trend analysis, as no formal statistical tests were conducted in this study.

While both ponds had mineral and water quality parameters within acceptable limits, Pond 1 showed greater stability in mineral concentrations and yielded a successful harvest of 90 kg with 90% survival. In contrast, Pond 2 exhibited greater fluctuations in magnesium levels and no harvest was recorded, likely due to predation. These differences highlight the role of mineral stability and external ecological factors in farming success.

**Table 3.** The role and benefits of minerals in shrimp cultivation.

| Type of requirement | Required minerals | Required amount |
|---|---|---|
| Larva | Ca | 240 ppm |
| | Mg | 300 ppm |
| Molting | Ca, Mg, Na, K | 0.36 % |
| Hatchery | Ca, Mg, Zu, Fe | Still needs to be researched |
| Immune response | Ca, Mg, Cu, Zn, Se | 0.3 ppm (to be added to feed) |

**Tabel 4.** Water quality data of Pond 1 and Pond 2.

| Water Quality Data Throughout the Research | | | | Quality standard |
|---|---|---|---|---|
| **Round 1** | | | | |
| **Parameter** | **TS1** | **TS2** | **TS3** | |
| Temperature | 31.80 | 31.40 | 31.40 | 28 - 32 ºC |
| pH | 7.80 | 7.29 | 7.44 | 6.8- 8.7 |
| Salinity | 17.62 | 17.80 | 17.88 | 10 –35 ppt |
| DO | 5.71 | 5.29 | 5.76 | 4-8 mg/L |
| **Round 2** | | | | |
| Temperature | 31.67 | 32.00 | 31.67 | 28 - 32 ºC |
| pH | 7.62 | 7.48 | 7.56 | 6.8- 8.7 |
| Salinity | 17.35 | 17.33 | 17.30 | 10 –35 ppt |
| DO | 5.87 | 5.68 | 5.54 | 4-8 mg/L |

## Discussion

The mineral requirements of shrimp have not been a major focus of research. Early studies concluded that shrimp cultivated in extensive systems typically do not require mineral supplementation and instead rely on dissolved minerals in the water, substrates, and natural feed (16). However, to optimize production, aiming for faster growth, higher stocking density, greater biomass, and shorter production cycles, mineral requirements should be prioritized in shrimp farming (12). Minerals can be classified into essential minerals, conditionally essential minerals, and non-essential minerals. Determining whether a mineral is essential is an important first step before assessing its need in animals. As defined by Frieden (1984), a nutrient is considered essential when a deficiency in its intake leads to a decline in physiological function, and the restoration of this nutrient results in the recovery of physiological functions. Thus, essential minerals must be provided in the correct amounts and in a biologically available form (17).

The mineral requirements of aquatic animals depend on their living stage (see **Table 3**). Marine decapods are osmotic conformers, with their salt concentrations being comparable to that of their surrounding environment, with minimal variation in the concentration of specific ions (18). In contrast, estuarine species maintain ion concentrations in their hemolymph that are higher than those of the surrounding water (hyperosmotic regulation). In such situations, the organisms continuously absorb unwanted water through osmosis and lose minor ions through passive diffusion (19). Penaeid shrimp, such as *Penaeus monodon*, are typically euryhaline, meaning they can tolerate a wide range of salinities. For example, *Penaeus monodon* can undergo hyperosmotic regulation in low-salinity water and become hypo-osmotic in high-salinity water (20). This ability allows *P. monodon* to grow and survive comparably when cultured in salinities ranging from 10 to 35 ppt.

While both ponds showed adequate mineral profiles, cultivation outcomes differed: Pond 1 yielded a successful shrimp harvest, while Pond 2 did not. This contrast suggests that other factors beyond mineral levels, such as predation, as reported by the pond owner, likely influenced shrimp survival in Pond 2. No evidence of disease, poor water quality, or stocking density issues was observed during the study period. Fluctuations in mineral values in Pond 2 were more pronounced than in Pond 1, especially for magnesium. However, these fluctuations did not exceed known tolerance thresholds for *Penaeus monodon*. As such, while mineral variability may have contributed to stress, it was not the primary limiting factor in production. The observed outcomes support the hypothesis that consistent and balanced mineral availability contributes positively to shrimp growth. However, pond management practices, such as predator control and environmental monitoring, must also be optimized to ensure successful cultivation.

The water quality in the ponds measured in this study includes physical parameters (temperature) and chemical parameters (pH, salinity, and dissolved oxygen). Water quality significantly impacts the growth of shrimp. These water quality measurements also serve to assess the suitability of pond water for shrimp farming. According to the WWF-Indonesia Fisheries Team (2014), the ideal water quality range for Penaeus monodon during cultivation is shown in **Table 4**. The water quality in the Karang Harapan and Tanjung Pasir ponds, in terms of temperature, salinity, pH, and dissolved oxygen, remains within the acceptable range for shrimp farming (21).

The success of shrimp pond aquaculture is highly dependent on water quality, particularly parameters such as pH, salinity, and dissolved oxygen (DO). Water pH plays a crucial role in the metabolic functions of aquatic organisms, with tolerance levels varying based on several factors, including temperature, dissolved oxygen levels, alkalinity, the presence of anions and cations, as well as the species and life stage of the organism. For *Penaeus monodon*, the ideal pH range is between 7.5 and 8.7, with an optimal value of 8.0–8.5. Salinity also has a direct effect on aquatic organisms by influencing the osmotic pressure of body fluids. In coastal waters, salinity levels are greatly affected by freshwater inputs from river systems (22). Although *P. monodon* is euryhaline and can tolerate salinities from 3 to 45 ppt, optimal growth is generally achieved at 15–25 ppt. In addition, dissolved oxygen concentration is a critical parameter for evaluating water quality. DO measurements in this study ranged from 5.29 to 5.87 mg/L across sampling points, indicating levels that remain within acceptable thresholds for the culture of *P. monodon*.

## Conclusion

The results of this study indicate that the concentrations of minerals, namely magnesium (Mg), calcium (Ca), and iron (Fe), measured in both Pond 1 and Pond 2 remained below the maximum permissible limits set by the Indonesian Water Quality Standards. According to the standards, acceptable concentrations are <60–100 mg/L for magnesium, <100–250 mg/L for calcium, and <0.1–0.5 mg/L for iron. These levels suggest that the presence of these minerals does not pose a risk to shrimp aquaculture, particularly for *Penaeus monodon*. Furthermore, the water quality parameters, temperature, salinity, pH, and dissolved oxygen, were all within the recommended ranges for shrimp farming throughout the study period. It was also observed that water quality conditions had no significant effect on mineral concentrations in the pond environments. Future studies should examine the potential role of predation and sediment composition on shrimp survival and mineral fluctuations, especially in extensive pond systems.

## Declarations

### Author Informations

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### Conflict of Interest

The authors declare no conflicting interest.

### Data Availability

The unpublished data is available upon request to the corresponding author.

### Ethics Statement

Not applicable.

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# Additional Information

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