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Water quality at silvoaquaculture pond in indramayu regency

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Abstract. Silvoaquaculture is one of environmentally friendly aquaculture, which is integration between fish ponds (brackish water aquaculture) and mangrove tree in the coastal area. In Indramayu Regency, silvo-aquacultures are located in Karangs ong, Brondong and Tegur village. Milk fish (Chanos chanos) was cultured at silvo-aquaculture in Indramayu Regency. The objective of this study is to know water quality at silvo-aquaculture ponds in Indramayu Regency. The water quality has been measured includes temperature, salinity, pH, brightness, DO, nitrate, phosphate, and ammonia. The ranges of water quality values at silvo-aquaculture ponds in Indramayu Regency are Brondong Village {temperature (29.8-33.0 °C), salinity (26-30 ppt), pH (7.27-7.80), brightness (26.5-91 cm), DO (3.1-10.7 mgL-1), nitrates (12.5 mgL⁻¹), phosphates (0.03 mgL⁻¹), and ammonia (0.25 mgL⁻¹)}; Karangsong Village {temperature (29.5-31.0 °C), salinity (17-25 ppt), pH (7.29-7.51), brightness (39.5-47 cm), DO (2.2-4.4 mgL⁻¹), nitrates (12.5 mgL⁻¹), phosphates (0.03 mgL⁻¹), and ammonia (0.25 mgL⁻¹)}; and Tegur Village {temperature (30.4-31.8 °C), salinity (15-19 ppt), pH (7.14-8.18), brightness (32.25-45.25 cm), DO (8.8-9.5 mgL⁻¹), nitrates (12.5 mgL⁻¹), phosphates (0.03 mgL⁻¹), and ammonia (0.25 mgL⁻¹)}. Analysis of variance showed temperature, pH, brightness, phosphate, nitrate, and ammonia were not significantly different between locations, but salinity and DO were significantly different between locations. These results indicate all water-quality parameters are suitable for fish culture. The lower salinity presented in Tegur Village was affected by rainy. Interestingly, DO concentrations in the Karangsong silva-aquaculture pond are lower than optimal value (<5.00 mg/l), but they are still suitable for milkfish life (> 2 mg/l).

1. Introduction
Pond cultivation has long been one of the main livelihoods of the community in the coastal area. The development of ponds has degraded the existence of mangrove ecosystems. In Indramayu, in 2000-2014 it was predicted that around 689 ha of mangroves had been lost and one of them was caused by the development of ponds [1]. The sustainability of mangroves must be maintained because damage to the mangrove ecosystem also affects the sustainability of fish farming [2]. Cultivation design that integrates mangrove and aquaculture will be able to prevent mangrove damage and maintain community welfare.

In the Indramayu coastal area, milkfish (Chanos chanos) culture has developed using silvo-aquaculture techniques. Silvo-aquaculture is an environmentally friendly cultivation technique that integrates between pond cultivation and mangrove forest. The integration between the conservation of mangrove and ponds in the form of silvo-aquaculture [3] is a mutually beneficial solution between mangrove conservation and aquaculture [4].

Water quality greatly determines the production of milkfish cultivation in ponds. The presence of mangroves in silvo-aquaculture ponds will be able to maintain the quality of pond water because mangroves are able to act as water pollution biofilter [5] so that the productivity of the pond remains
high [6]. This research examines the characteristics of silvoaquaculture pond water quality in the three villages (Karangsong, Brondong, and Tegur) in Indramayu Regency. The coastal environment conditions of each different villages are expected to affect the quality of pond water for each village can be different.

2. Research Methods

This research was conducted in Indramayu Regency (Karangsong, Brondong, and Tegur Villages). Water quality measurements were carried out in June 2019. The number of water quality observation stations was 21 stations, where each village had 7 observation stations. Water quality measurements are carried out in pond waters, inlets, and outlets. Water quality data measured include temperature, salinity, pH, brightness, dissolved oxygen (DO), phosphate, nitrate, and ammonia. All water quality was measured in situ using TDS-meter, refractometer, seccidisc, DO-meter, and water quality kit.

Water quality data were analyzed qualitatively using criteria for water quality criteria for fish farming [7]. Analysis of water quality data was also carried out quantitatively using an analysis of variance of Kruskal-Wallis test and the results of different types of analysis carried out using the Mann-Whitney test.

3. Results and Discussion

The distribution of silvoaquaculture pond water quality in the three villages in Indramayu District is presented on Table 1. Water quality data which includes temperature, salinity, pH, brightness, dissolved oxygen (DO), phosphate, nitrate, and ammonia in the three villages are classified as suitable for milkfish cultivation.

Temperatures range from 29.5-33.0 °C, with the lowest temperature found in the village of Karangsong and the highest temperature found in the village of Brondong. Fish can live in a temperature range of 15-35 °C and live well at temperatures of 20-30 °C [7]. Based on these criteria, the water temperature in all observation stations is appropriate for the life and growth of milkfish. Water temperature will affect the fish’s metabolic rate and physiological processes of fish which will affect fish growth [8-9]. The ideal temperature will support the high production of milkfish.

The temperature difference at each station is caused by differences in observation times, where morning observations produce low temperatures and daytime observations produce high temperatures. The results of the variance analysis showed that the quality of silvoaquaculture pond water in the three villages was not significantly different (Table 2). These temperature characteristics indicate that silvoaquaculture area in Indramayu Regency is suitable for milkfish cultivation.

| Parameter | Unit | Karangsong | Brondong | Tegur | Acceptable range | Desirable range | Stress |
|-----------|------|------------|----------|-------|------------------|----------------|--------|
| Temperature | °C | 29.5-31.0 | 29.8-33.0 | 30.4-31.8 | 15-35 | 20-30 | <12, >35 |
| Salinity | ppt | 17-25 | 26-30 | 15-19 | 0-60 | 10-25 | - |
| Brightness | cm | 39.5-47 | 26.5-91.0 | 32.25-48.25 | - | 30-80 | <12, >80 |
| pH | 7.29-7.51 | 7.27-7.80 | 7.14-8.18 | 7.0-9.5 | 6.5-9.0 | 4, >11 |
| DO | mgL⁻¹ | 2.2-4.4 | 3.1-10.7 | 8.8-9.5 | 3-5 | 5-8 | 5, >8 |
| Phosphate | mgL⁻¹ | 0.03 | 0.03 | 0.03 | 0.03-2 | 0.01-3 | >3 |
| Nitrate | mgL⁻¹ | 12.5 | 12.5 | 12.5 | <100 | 0.1-4.5 | >100, <0.01 |
| Ammonia | mgL⁻¹ | 0.25 | 0.25 | 0.25 | <0.05 | 0.025 | >0.3 |

Salinity shows the salt content of the water. Different salinity levels affected on fish growth [10]. Milkfish are classified as euryhaline fish that can live in a wide range salinities. The salinity range at the observation site ranges from 15-30 ppt. The distribution of salinity in all observation stations is good because milkfish live well at salinity of 10-25 ppt [7]. Salinity will affect the fish osmoregulation process [11]. Appropriate salinity for fish conditions good osmoregulation so that fish growth will also be good.
The results of the variance analysis showed that salinity in the three locations was different (Table 2). Mann-Whitney’s test results (Table 3) provided information that between silvo-aquaculture ponds in Brondong, Karangsong, and Tegur villages had significantly different salinity. The lowest salinity is found in the Tegur village as a result of rain and freshwater flow from the Cimanuk river.

Brightness is an indicator of the total intensity of light in the water body [12]. The brightness of silvo-aquaculture pond water in each village was not significantly different (Table 2). The brightness ranges from 26.5-91.0 cm. The brightness distribution is quite good because fish is feasible at a brightness value of 30-80 cm. At station 3 in the Brondong village has a high brightness (> 80 cm) which can affect fish stress. The existence of mangrove trees will provide shade for the waters so that the negative effects of sunlight on aquaculture fish can be reduced.

pH indicates the acidity [13] of pond water and it is one of the critical factors that limit the survival rate of aquatic organisms [14]. The ideal pH for fish ranges from 6.5-9.0 [7]. The water quality of silvo-aquaculture ponds showed a range between 7.14-8.18 which indicates that the pH of water is ideal for milkfish cultivation. The results of variance analysis (Table 2) showed that each location had a relatively similar pH so that the pH values in all locations of silvo-aquaculture ponds were ideal for the survival and growth of milkfish.

| Table 2. The results of the variance analysis of water quality between locations based on the Kruskal-Wallis analysis |
|-----------------------------------------------|
| Water Quality | Asymp.Sig. | Information |
|----------------|-----------|-------------|
| Temperature    | 0.505     | not significantly different |
| Salinity       | 0.000     | significantly different |
| Brightness     | 0.953     | not significantly different |
| pH             | 0.100     | not significantly different |
| DO             | 0.040     | significantly different |
| Phosphate      | 1.000     | not significantly different |
| Nitrate        | 0.591     | not significantly different |
| Ammonia        | 1.000     | not significantly different |

Dissolved oxygen (DO) is the water quality which plays an important role [15] in the process of fish respiration [16]. In waters that are low in oxygen content, fish will be weak and can experience death [16-17]. The results of the analysis of variance of each village had a different DO (Table 2), and the results of the Mann-Whitney test showed the oxygen content of the waters of each village was different, except between the village of Brondong and the village of Tegur (Table 3).

Dissolved oxygen in a silvo-aquaculture pond in Karangsong village ranged from 2.2-4.4 mgL⁻¹. This dissolved oxygen level was lower than DO in silvo-aquaculture pond in the village of Brondong and the village of Tegur. The location of silvo-aquaculture ponds in Karangsong village is close to the ship’s traffic flow and the fishing port of Indramayu so that the waters in this area receive a higher pollution impact compared to other villages. Pollution sources in Karangsong come from the activities of fishing port, agriculture, shipbuilding industries, tourism, and fish auction sites [18]. This pollution is thought to cause dissolved oxygen in silvo-aquaculture ponds in the Karangsong village to be lower. Fish are still able to live at oxygen levels below 1.5 mgL⁻¹, but the growth is not optimal [19]. Dissolved oxygen content 5-8 mgL⁻¹ is the ideal range for fish farming [7]. Oxygen levels in silvo-aquaculture ponds in the Karangsong village range from 2.2-4.4 mgL⁻¹ classified as suitable for the life of milkfish, but not good for milkfish growth (below the optimal value). Dissolved oxygen levels in silvo-aquaculture ponds in the Brondong village (3.1-10.7 mgL⁻¹) were included in the criteria to be feasible until optimal, while the dissolved oxygen levels in silvo-aquaculture ponds in the Tegur village (8.8-9.5) were classified as optimal for the growth of milkfish.
Table 3. The results of Mann-Whitney test at salinity and dissolved oxygen

| Parameter | Location 1 | Location 2 | Sig.       | Information       |
|-----------|------------|------------|------------|-------------------|
| Salinity  | Karangsong | Brondong   | 0.002      | significantly different |
|           | Karangsong | Tegur      | 0.008      | significantly different |
|           | Brondong   | Tegur      | 0.002      | significantly different |
| DO        | Karangsong | Brondong   | 0.047      | significantly different |
|           | Karangsong | Tegur      | 0.021      | significantly different |
|           | Brondong   | Tegur      | 0.654      | not significantly different |

Ammonia is a dissolved gas in the waters that are toxic to fish [20-21]. The effect of ammonia toxicity dependent on temperature and pH [21]. Ammonia content that is good for fish farming is a maximum of 0.025 mgL⁻¹[7]. Total ammonia levels in silvo-aquaculture pond water in all research locations were 0.25 mgL⁻¹. This ammonia content is higher than the optimal value for fish growth but is lower than the fish stress limit (ammonia levels >0.03 mgL⁻¹), so that this ammonia level is still safe for milkfish survival.

Ammonia in silvo-aquaculture pond waters come from the biological decomposition [21] of the remaining feed and the rest of the metabolism of fish [22]. About 75% of the feed is not eaten by fish [10] and dissolved in water as organic waste which has the potential to produce ammonia. The frequency of replacement of pond water which follows caused organic matter and ammonia to be formed that are not quickly wasted out of the pond.

Phosphate and nitrate are water quality associated with aquatic nutrients [23,24,25]. The presence of phosphate and nitrate in the waters is needed for the growth of plankton [24, 25]. The presence of nitrate and phosphate in silvo-aquaculture pond waters is needed to grow plankton as natural food for milkfish seeds. Phosphate and nitrate are not toxic, even so at phosphate levels above 3 mgL⁻¹ and nitrate above 100 mgL⁻¹ can cause fish stress [7,26]. Nitrate and phosphate content in silvo-aquaculture ponds in all research locations are uniform, that is nitrate of 12.5 mgL⁻¹ and phosphate of 0.03 mgL⁻¹, so that was considered good for milkfish cultivation.

4. Conclusion
Silvo-aquaculture pond water quality in Indramayu Regency is in the proper and optimal range for milkfish cultivation. Almost all parameters of silvo-aquaculture pond water quality in each village are relatively the same, except for salinity and DO.

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