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DETERMINATION OF TEMPERATURE, pH, SALINITY, DO, TDS, TSS, AND NITRITE CONTENT IN 42-DAY-OLD SHRIMP FARMING PONDS

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ABSTRACT

This study was to determine water quality in shrimp farming through parameters such as temperature, pH, salinity, dissolved oxygen (DO), total suspended solids (TSS), and total dissolved solids (TDS). Databases for all shrimp farms were created. Water quality heavily impacts shrimp health, growth, and disease susceptibility. TDS and TSS were determined by gravimetric analysis, and nitrite was determined by UV-Vis spectrophotometry at 545 nm. Inlets, ponds and outlets were sampled to compare quality differences. The highest temperature (27.9°C) and DO (7.23 mg/L) values were found in the pond, while the inlet had the highest pH (7.54) and salinity (19 psu). TSS (0.055 mg/L) and TDS (20.460 mg/L) were highest in the inlet too. The nitrite levels at the inlet, pond and outlet were an average of 0.0073, 0.0249 and 0.0501 mg/L respectively. Nitrite in shrimp feed was 0.0535±0.0029 mg/L. The analytical parameters for detecting quercetin were excellent linearity with R^2 = 0.9959, precision with CV Horwitz ≤10.14%, and accuracy with 90.33–95.04%. The results showed that temperature, pH, salinity, DO, TSS, and TDS levels are suitable and that the acceptable nitrite concentration of the samples fits into the criteria for sustainable shrimp farming.

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INTRODUCTION

Shrimp is one of the fisheries sectors with high economic value and protein sources for community food, so it has the potential to be developed in Indonesia. In Indonesia, the highest value of shrimp exports in the 2017-2022 period saw USD 2.23 billion in 2021 but declined to USD 2.16 billion with a decrease of 3.22 percent in 2022. Nevertheless, Indonesian shrimp exports did grow at an average rate of 4.61 percent per annum overall [1]. Shrimp farming has merits, such as developing disease-resistant varieties and high yields. Shrimp can be further raised as they are more efficient in feeding and space use. This causes many farmers to grow it [2]. Both environmentally harmful and energy-consuming activities result from intensive shrimp farming development by stocking at high density and applying great quantities of feed. However, shrimp farming has consequences for the environment. Effluents discharged directly are vulnerable to pollution of the surrounding waters and soil quality. The discharged effluents may lower the dissolved oxygen, hypernutrification, eutrophication, and incriminating sedimentation burden [3].

Your cultivation business's success depends on the water quality you use. Nitrite is Livestock and Poultry Feed Ingredients. High nitrite can lead to shrimp poisoning and death. For this reason, monitoring nitrite in shrimp culture is critical to preserve water quality and shrimp health. Water quality is also affected by toxic compounds due to high nitrite-containing feed and leftover feed that is not consumed by shrimp [4]. Therefore, maintaining water quality requires proper monitoring. By adding probiotic bacteria, which can relieve the nitrite levels in the waters, the decomposition process of organic compounds into minerals for phytoplankton can be speeded up, improving water quality. Ammonia and nitrite can be removed using phytoplankton to help control water quality [5]. Phytoplankton utilizes it to create photosynthesis, as does oxygen during creation. Still, a tremendous amount of dense phytoplankton (algae bloom) gives an overabundance of daytime oxygen but a balance of a relatively modest amount at night. It will kill off phytoplankton and shrimp raised for farming.

In a process that emits toxin compounds, it could perform to become more. Screening nitrite levels and some physical and chemical parameters in shrimp ponds to assess the toxic compounds should be applied to screen the issuing algae bloom condition. Temperature, pH, salinity, Dissolved Oxygen (DO), Total Dissolved Solid (TDS), Total Suspended Solid (TSS), and nitrite (NO_2-N) are some physical and chemical parameters that can be tested. This moment has been investigated because nitrite is the primary product of the oxidation reaction in the nitrogen cycle. Based on the Regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 75 of 2016 regarding General Guidelines for Enlargement of Tiger Shrimp and Vannamei Shrimp, the nitrite content in water is allowed a maximum of 0.06 mg/L. This study also measures several water quality parameters, namely temperature, pH, salinity, Dissolved Oxygen (DO), Total Dissolved Solid (TDS), and total suspended Solid (TSS).

This study was preplanned to determine the water quality parameters, e.g., temperature, pH, salinity, dissolved oxygen, TDS, and TSS. Penetapan nitrit (NO_2-N) dengan metode UV-Vis spektrofotometer berdasarkan SNI 06-6989.9 tahun 2024 [6]. Even though it has versatile, simple, feasible, and remarkable limits of detection achieved and facile assay-type protocols [7], [8], this test method is performed under acidic conditions at pH 2.0–2.5. Nitrite-positive samples will produce a purplish red azo compound when reacted with sulfanilamide and NED Dihydrochloride. Water quality is measured because water quality has a significant effect on growth and health of shrimp. Journal of Cleaner Production, 140(P2): 738–746, 2017. 5-Hantavirus Pulmonary Syndrome — USA, 2003 6–Hantavirus Infection in Humans — Setting New Standards for Hantavirus Pulmonary Syndrome — USA, 1993–1995 7-1-Water

Quality — 2002–2005 Aclamide in farm environments: Long term monitoring of shrimp disease susceptibility focused on farm monitoring of poor water quality. Bad water conditions can also stunt shrimp growth, cutting farmers' profits. Thus, water quality management must be effective in maintaining productive cultivation.

METHODS

1. Equipment

This test uses UV-vis spectrophotometry, a set of glassware, a water bath, an analytical balance, a vacuum device, a pH meter, a DO meter, and a refractometer.

2. Material

The materials used in this test are sulfanilamide, NED Dihydrochloride, $NaNO_2$ solution, sodium chloride (NaCl), magnesium chloride hexahydrate ($MgCl_2.6H_2O$), sodium sulfate decahydrate ($Na_2SO_4.10H_2O$), Aquades, filter paper**.**

3. Analysis of temperature, pH, salinity, and dissolved oxygen (DO)

In the shrimp pond, samples were taken as pooled samples. After collecting samples, they were stored in a cool tank, and then the sample was transported to the laboratory for analysis. Temperature, pH, salinity, and dissolved oxygen (DO) parameters were measured directly in the field.

4. TDS Analysis

The clean porcelain cup is opened at 180°C for 1 hour, then transferred to a desiccator for 30 minutes. After cooling, immediately weigh and record as constant weight (W_o in mg). The test sample is shaken until homogeneous and then measured using a 50 mL centrifuge tube. The test sample is inserted into the filter of the suction pump and filter media. The filtered filtrate is collected using a 50 mL beaker. The filtrate is taken as much as 25 mL into a porcelain cup and then evaporated into a water bath until all is evaporated. After that, the porcelain cup is placed in an oven at 180°C for 1 hour. The porcelain cup is transferred to a desiccator for 30 minutes. The porcelain cup is weighed until a constant weight is obtained (W_1 in mg).

5. TSS Analysis

The filter paper was rinsed with distilled water and continued to be sucked until it drained. The filter paper was transferred to a porcelain cup and dried in an oven at 105°C for 1 hour. The porcelain cup was cooled in a desiccator for 30 minutes and weighed at a constant weight (W_o in mg). The test sample was shaken until homogeneous and then measured using a 50 mL centrifuge tube. The test sample was inserted into the filter of the suction pump and filter media. The filter paper was transferred to a porcelain cup and dried in an oven at 105°C for 1 hour. Then cooled in a desiccator for 30 minutes and weighed until a constant weight was obtained (W_1 in mg).

6. TDS and TSS Calculation

The determination of Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) in shrimp farming ponds at 42 days of cultivation is based on the following equation:

$$\mathrm{TDS/TSS} = \frac{(W_1 - W_o)}{V} \mathrm{x1000}$$

Where:

W_o : Weight of empty porcelain cup (mg)
W_1 : Weight of porcelain cup+sample (mg)
V : Sample volume (mL)
1000 : milliliter to liter conversion

This is one of the most crucial calculations in monitoring water quality for shrimp farming ponds. The total dissolved salt (TDS) indicates the concentration of ions in the water, affecting the salinity and osmoregulation of shrimp. Anything detectable by light, like dust, plant material, microorganisms, etc. TSS = total suspended solids. Both parameters are essential to ensure suitable environmental conditions for the specific requirements of shrimp health and growth during the entire farming period of 42 days. While water quality is also typically assessed through temperature, pH, salinity, dissolved oxygen (DO), and nitrite content, this method adds a quantitative level of understanding to the pond ecosystem.

7. Nitrite Determination (NO_2-N)

a. Preparation of sulfanilamide solution

A total of 5 grams of sulfanilamide was dissolved in a mixture of 300 mL of distilled water and 50 mL of concentrated HCl, then put into a 500 mL measuring flask, and distilled water was added to the boundary mark and homogenized.

b. Preparation of NED Dihydrochloride solution

As much as 0.5 grams of NED Dihydrochloride is dissolved in distilled water. The solution is put into a 500 mL measuring flask, added with aquadest to the boundary mark, and homogenized. Store in a dark bottle.

c. Preparation of Nitrite standard solution (NO_2-N)10 mg/L

The nitrite (NO_2-N) stock solution of 304 mg/L was pipetted as much as 1.6 mL and put into a 50 mL measuring flask, then artificial seawater was added to the mark and homogenized.

c. Preparation of standard Nitrite solution (NO_2-N)

Standard nitrite solution (NO_2-N) 10 mg/L was pipetted in amounts of 0, 0.1, 0.2, 0.5, 1, 1.5, and 2 mL each into a 100 mL measuring flask, and artificial seawater was added to the mark. The nitrite levels obtained were 0, 0.01, 0.02, 0.05, 0.10, 0.15, and 0.20 mg/L.

d. Determination of Nitrite (NO_2-N) levels in samples

The test sample obtained from the inlet, pool, and outlet was filtered and pipetted to as much as 10 mL and put into a test tube. The test sample was added with 0.2 mL of sulfanilamide solution, shaken, and left for 2-5 minutes. The sample was added with 0.2 mL of NED Dihydrochloride solution, shaken, and left for 30 minutes. The absorbance of the solution was read at a maximum wavelength of 545 nm.

8. Method Validation

a. Limit of Detection (LOD) and Limit of Quantification (LOQ)

The detection and quantification limits in determining nitrite levels are calculated from the linear regression equation's residual standard deviation and slope values . The residual standard deviation is determined from the absorbance measurement of the standard series that has been corrected with the linear regression equation. Determination of the detection limit and quantification limit refers to the Indonesian National Standard procedure for nitrite [6]. According to the literature [9], the limit of detection (LOD) and limit of quantification (LOQ) were estimated by regression parameters, respectively, as 3.3sy/x/a and 10sy/x/a, where the symbol 'sy/x' was the residual deviation of the regression and 'a' was the slope of the calibration curve

b. Precision

Precision is a measure of the relative standard deviation (RSD) and is expressed as the repeatability of an analytical method. [10]. Precision is the correlation of measurement results in the same conditions that are carried out repeatedly. A good precision value is <2%; if it exceeds it, it is compared with %CV Horwitz.

c. Accuracy

The sample was pipetted to as much as 9 mL, and 1 mL of 0.05 mg/L NO2-N standard solution was added and then put into a test tube. Spike matrix was added with 0.2 mL of sulfanilamide and 0.2 mL of NED Dihydrochloride, then shaken and left for 30 minutes. The absorbance of the solution was read at a maximum wavelength of 545 nm.

RESULTS AND DISCUSSION

1. Temperatur

The temperature of Outflow According to Table 1, in-place data was obtained. The temperature measurement inlet obtained 27.8oC, the pond obtained 27.9oC, and the outlet obtained 26.7ºC. Temperature is one of the parameters that support the growth of shrimp, and the optimum temperature level for shrimp cultivation is in the range of 26–30°C [11]. The temperature level in this study is disclosed in the water quality standard. In the end, several factors influence temperature; one that makes an impact is the weather since the hotter the environment, the higher the temperature of the water; this is due to the heat absorption process that water emits.

Table 1. Water Quality Parameter Data

Parameters	Inlet	Pond	Outlet
Temperature (ºC)	27.8	27.9	**26.5**
TSS (mg/L)	0.0550	0.0390	**0.0480**
TDS (mg/L)	20.4600	17.4200	**17.6760**
pH	7.54	7.50	**7.47**
Salinity (ppt)	19	17	**16**
DO (mg/L)	**6.75**	**7.23**	**6.13**

2. TSS dan TDS

Table 1 shows the results of TDS and TSS tests conducted on shrimp farm air samples at the age of 42 days. The inlet, pond, and outlet TSS parameter analysis results were 0.0550 mg/L, 0.0390 mg/L, and 0.048 mg/L, respectively. In contrast, the inlet, pond, and outlet TDS results were 20.460 mg/L, 17.420 mg/L, and 17.676 mg/L, respectively, class III, where physical parameters according to TSS <100 mg/L and TDS <1,000 mg/L are mandatory according to Government Regulation of the Republic of Indonesia No. 22 of 2021 concerning the Implementation of Environmental Protection and Management [12].

3. pH

The pH measurement at the inlet yielded 7.54. It was 7.50 in the pond — 7.47 out of the outlet. A characteristic that was reported to be optimal for shrimp cultivation in this test was pH, which was 6.5-9 — the normal pH that should be present in the process of shrimp growth [13], [14]. pH is an important factor in water quality as many aquatic chemical dynamics are pH-dependent. Low or high water pH can send shrimp into stress, producing soft shells and low survival [15]. Acidic waters are often lethal to fish, and pH values are too alkaline. A low (8.5) water pH can also induce stress in shrimp and cause soft shrimp shells and low shrimp survival [16].

4. Salinity

The salinity measurement results in the inlet were at 19 pm, the pond at 17 pm, and the outlet at 16 pm. Now, one can say that these results are good for shrimp growth. Based on Dwisaputra et al. [17], Ideal salinity 12-20 Salinity is one of the basic environmental factors [18]. Salt is another major ecological factor that influences shrimp's survival, development, and physiology function [19]. Extreme changes in salinity can influence multiple physiological functions of shrimp [20], [21]. High salinity is the main factor that inhibits shrimp growth in high-density cultivation processes [22]. The osmoregulation process and the molting process are influenced by salinity. At higher salinity levels, the growth of shrimp would slow down since the energy owned by shrimp goes to more osmoregulation than growth.

5. Dissolved Oxygen (DO)

Dissolved oxygen (DO) consists of gaseous oxygen dissolved in water and used by aquatic organisms to satisfy their oxygen requirements [23]. DO level is usually expressed as mg/L or as percent saturation [24].

Oxygen dissolved in water (DO) is an important water quality parameter in aquaculture systems, as aerobic organisms depend on appropriate oxygen levels for their biochemical processes. Dissolved oxygen concentrations will vary dynamically due to biological, physical, and chemical processes. Shrimp are aquatic biota that need oxygen for bioenergy balance in their metabolic systems in intensive cultivation. The growth stage and feeding rate in shrimp also affect oxygen uptake rates. Thus, it can be said that the low metabolic rate of reaction of O_2 consumption had a significant impact on the metabolic condition of the shrimp when growing and active [25].

Dissolved oxygen measurements indicated 6.75 ppm for the inlet, 7.23 (mg/L) for pool and outlet, and 6.13 (mg/L). Under temperature and high salinity content, dissolved oxygen will be low. According to the Indonesian Standards Agency [26], good dissolved oxygen for shrimp is >4 mg/ L. As for dissolved oxygen, the process of photosynthesis contributes to water oxygen. Due to this mechanism of photosynthesis into the process of respiration by macrophytes due to sun [27].

The presence of dissolved oxygen (DO) in either water is regarded as one of the most critical factors influencing the prosperity and growth of shrimp [28]. Anoxia, slow growth, and shrimp death can occur due to low dissolved oxygen in the water [29]. On the contrary, shrimp cultured under high oxygen concentrations improved their health status, reduced stress, and enhanced the immune response of shrimp; significant growth performance was observed in shrimp reared in higher oxygen concentrations than in low oxygen conditions [30].

6. Nitrite (NO_2)

The UV-Vis spectrophotometry method with a maximum wavelength of 545 nm refers to the National Standards Agency number 06-6989.9-2004 [6] and is used for nitrite testing in shrimp farming ponds. This method is used because it has high sensitivity, selectivity, and accuracy, which proves an appropriate molecular method to measure a sample [31]. This is based on the principle that nitrite in the sample reacts with sulfanilamide to form an azo intermediate compound. Subsequently, the intermediate compound combines with NED Dihydrochloride to yield a purple azo compound. The sulfanilamide solution reagent serves as a complex agent, while NED Dihydrochloride serves as a catalyst. Figure 1. Azotation reaction in nitrite tests. The outcome of nitrite testing can be viewed in Table 2.

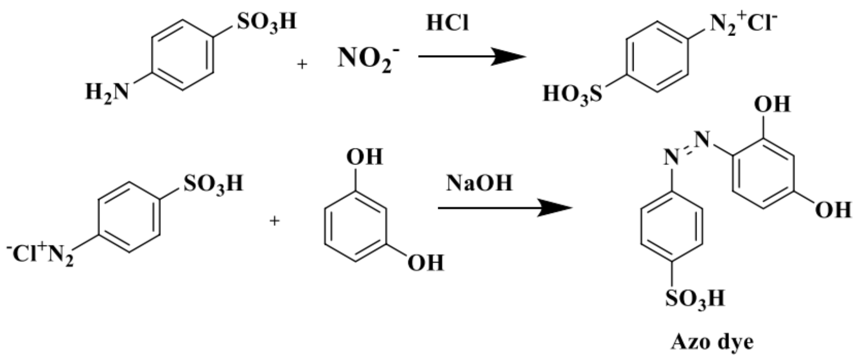

Figure 1. Annotation Reaction in Nitrite Testing [32], [33]

Table 2. Nitrite concentration in shrimp ponds

Repetition	NO_2- N (mg/L)			Threshold
	Inlet	pond	Outlet	
1	0.0074	0.0280	0.0461	< 1 mg/L
2	0.0076	0.0223	0.0505	
3	0.0061	0.0217	0.0474	
4	0.0063	0.0253	0.0530	
5	0.0088	0.0267	0.0536	
Average	0.0072	0.0248	0.0501	

Table 2 shows the results of nitrite levels in ponds of shrimp farming obtained an average of 0.0072 mg/L, 0.0248 mg/L, and 0.0501 mg/L, where the maximum level of the parameter nitrite (NO_2-N) of <1 mg/L so that the concentration of nitrite shrimp pond declared to meet the Quality Standard requirement according to the Regulation of the Minister of Marine Affairs and Fisheries of Republic of Indonesia Number 75 Year 2016 on General Guidelines for the Enlargement of Tiger Shrimp and Vaname Shrimp [34].

In addition, nitrite compounds in natural pond water are the by-products of microbial metabolism, producing nitrite by reducing nitrate compounds (NO3) or the oxidation of ammonia. Additionally, nitrite compounds come from zooplankton excretion in natural pond water [35]. Thus, monitoring is needed to solve the rise of nitrite content in shrimp ponds. Maintaining good water quality will support optimal growth, whereas poor water quality will retard growth as reduced water quality causes stress leading to reduced appetite and even death. Water Quality in Shrimp Maintenance - Water quality in shrimp maintenance can be a benchmark for the success of cultivation [36].

7. Method Validation

7.a. Linearity

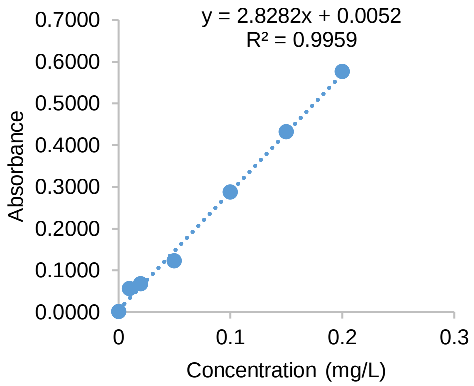

Figure 2. Linearity of Calibration Curve

It can be seen from the curve image in Figure 2 that the determination coefficient value (R2) = 0.9959 and correlation coefficient value (r) = 0.9979, it can be concluded that the nitrite (NO2-N) standard curve has linearity acceptance requirements, which is the correlation coefficient is at least R = 0.9950, while good determination coefficient value is R^2 = 0.9970 or near to one [5]. Thus, it is confirmed that the linear observation in estimating nitrite in samples and high correlation level on the present data.

a. Limit of Detection (LOD) and Limit of Quantification (LOQ)

The limit of detection (LOD) and limit of quantification (LOQ) corresponds to the lowest amount of reagent in a sample that can be detected and produces a significant response [5]. The LOD and LOQ are calculated from equations that consider the parameters of the analysis curve, with the standard deviation of the response and the slope of the curve [37]. The detection limit (LOD) value based on three standard deviation results was obtained at 0.0073 mg/L and the quantification limit (LOQ) value obtained at 0.0242 mg/L stated that the UV-Vis spectrophotometry instrument was able to give the small concentration of the analyte to be measurable. Since the obtained intercept was lower than the value of the limit of detection, it can be indicated that the value of the interference in analysis does not significantly impact determining the LOD and LOQ.

b. Precision

Precision is the degree to which the same measurement results under the same conditions can be repeated. The calculation results for the precision are shown in Table 3. If it exceeds, it is compared with %CVHorwitz, where good precision value results <2%. From Table 2, the %RSD at the inlet is 7.55% lower than %CV Horwitz, which is calculated based on the Horwitz equation, which indicates that the ability of the test to determine the target will be higher. The pool is recovered at 5.51%, smaller than the %CV

Horwitz of 9.61%. This is determined to be 3.31% less than the %CV Horwitz of 9.30%. The %RSD value from shrimp feed is generated at 2.93% and less than the value of %CV Horwitz at 9.27%. Thus, the precision in the test can be claimed to be good because the %RSD value was lower than that of CV Horwitz. This is, however, consistent with earlier studies that implemented HPLC [38] and UV-Vis spectrophotometry [39], [40].

Table 3. Precision Determination Data (%RSD)

Repetition	NO_2-N (mg/L)		
	Inlet	**pond**	**Outlet**
1	0.0074	0.028	0.0461
2	0.0076	0.0223	0.0505
3	0.0061	0.0217	0.0474
4	0.0063	0.0253	0.053
5	0.0088	0.0267	0.0536
Average	0.0072	0.0248	0.0501
SD	0.0005	0.0014	0.0256
%RSD	7.55	5.51	3.31
CV Horwitz	10.14	9.61	9.3

c. Accuracy

Accuracy is a metric that gives us an idea of how close the evaluation outcomes are to the actual outcome. Percent recovery (%Recovery) is used to express the accuracy. The addition method was employed in this study by spiking a concentration of a standard solution [37] to the sample. 0.05 mg/L was the concentration of 1 mL as far as 9 mL of 9 mL, and the sulfanilamide and NED Dihydrochloride reagents were added. Table 4 below shows the outcome of measuring accuracy.

The accuracy value (%R) for testing shrimp pond water samples was obtained at 90.33%, 92.73%, and 95.04%, while for test results on shrimp feed was 91.60%. Accuracy acceptance requirement 90-110% of the actual level [41]. The testing accuracy value on nitrite in 42-day-old shrimp ponds with simplified UV-Vis spectrophotometry can be categorized as good because it lies in the accuracy range of some previous methods such as HPLC [38], Ion Chromatography [42], UV-Vis spectrophotometry [39], [40].

Table 4. Accuracy Determination Data (% Recovery)

Category	Concentration (mg/L)		
	Inlet	**Pond**	**Outlet**
Sample Concentration	0.0072	0.0248	0.0501
Spike Concentration	0.0118	0.0295	0.0549
Target Concentration	0.0050	0.0050	0.0050
%recovery	90.33	92.73	95.04

d. Measurement uncertainty estimation

Measurement uncertainty is the unknown error value of a test [10]. Describe how the uncertainty flows from the error source, depending on the calibration curve concentration, test volume containing concentration, 10 mL measuring pipette, and precision characteristics through a fishbone diagram. The information shows the uncertainty of assessing water quality in 42-day-old shrimp cultivation in Table 5.

Table 5. Results of Uncertainty Values of Nitrite Levels

Sample	Concentration (mg/L)	Uncertainty Estimation (mg/L)	Result (mg/L)
Inlet	0.0072	0.0035	0.0072 ± 0.0035
Pond	0.0248	0.0041	0.0248 ± 0.0041
Outlet	0.0501	0.0044	0.0501 ± 0.0044

Using a coverage factor of 2 with a 95 percent confidence interval, the uncertainty for the test at the inlet was calculated to be 0.0035 mg/L, while the pool and outlet reported 0.0041 mg/L and 0.0044 mg/L, respectively. The greatest contributor was precision from the inputting test, which had sources of standard deviation factors, temperature factors, and the environment. Table 6 gives additional sources of uncertainty.

Table 6. Contribution of uncertainty to nitrite determination

Contributors to uncertainty	Percentage (%)		
	inlet	**pond**	**outlet**
calibration curve	1.56	1.80	2.26
10 mL measuring pipette	27.66	34.22	46.04
precision	70.78	63.98	51.71

CONCLUSION

The physicochemical analysis of water in 42-day-old shrimp farming ponds indicated favorable growth conditions, as all parameters fall within ranges considered acceptable for shrimp production. The temperature (inlet: 27.8°C, pond: 27.9°C, outlet: 26.7°C) was suitable for shrimp cultivation, favoring its metabolism and growth. It shows neither TSS (inlet: 0.0550 mg/L, pond: 0.0390 mg/L, outlet: 0.048 mg/L) nor TDS (inlet: 20.460 mg/L, pond: 17.420 mg/L, outlet: 17.676 mg/L) exceeds the standard applicable for Indonesian water quality standard, that helps water clarity and nutrient balance. The pH values (inlet: 7.54; pond: 7.50; outlet: 7.47) remained in the appropriate range of (6.5–9) (favorite value), avoiding stress in shrimp and improving survival rates. Shrimp growth was further aided by salinity measurements (inlet: 19 psu, pond: 17 psu, outlet: 16 psu) that were suitable for growth and ensured a lower risk of physiological stress. Dissolved oxygen (inlet: 6.75 mg/L, pond: 7.23 mg/L, outlet: 6.13 mg/L); above the minimum (>4 mg/L) required for shrimp metabolism. Nitrite (inlet: 0.0072 mg/L; pond: 0.0248 mg/L; outlet: 0.0501 mg/L) was below the threshold value (<1 mg/L), showing that the nitrite concentrations met the water quality standards. This shows that the pond system is an environmentally friendly environment that is by environmental regulations and can support the optimal growth of shrimp.

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