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RESEARCH ON CHANGES AND SOLUTIONS TO CONTROL ENVIRONMENTAL QUALITY IN CONCENTRATED SHRIMP FARMING AREAS IN QUANG NINH PROVINCE

Major: Soil and Water environment

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INTRODUCTION

1. Urgency of the thesis

Over the years, brackish water shrimp were identified as the main cultured species. In 2020, export turnover reached USD 3.73 billion; is expected to reach over 8.4 billion USD by 2025. However, the challenge of pollution, disease outbreaks in highly concentrated shrimp farming areas, especially intensive and super-intensive of shrimp farming. The quality of the water environment in the above farming methods indicated that there was a sign of organic pollution (BOD_5, COD) which was higher than the allowable standard, the presence of NH_4^+ nutrient pollution (ammonia) and toxic substances such as H_2S; in the sewage sludge accumulates shrimp feces, rotting leftovers were decomposed, residual chemicals were deposited into sediments; The soil in the pond tended to degrade after many years of monoculture shrimp farming. To overcome the above problems, there have been a number of studies on water environment changes in shrimp farming areas, proposing some measures to control the quality of supply water, pond water and shrimp farming wastewater. and apply. However, the quality of the environment has declined, and diseases still occur at different levels and frequencies, causing great damage to shrimp farmers.

Quang Ninh is the province with the largest concentrated shrimp farming areas in the North. Recently, the environmental quality of shrimp farming areas has also tended to decline, and at the same time, there have been many unexplained mass deaths of shrimp. Therefore, the thesis "**Research on changes and methods of environmental quality control in the concentrated shrimp farming areas in Quang Ninh province**" is carried out, having high scientific and practical significance.

2. Research objectives

To evaluate changes in quality of water supply and soil/sediment in

ponds in concentrated shrimp farming areas in Quang Ninh; Supply water, water in ponds, wastewater and sludge after farming ponds of concentrated shrimp farming areas in Tan An, Quang Yen, Quang Ninh province.

To propose a synchronous solution to control environmental quality in the concentrated shrimp farming areas in Quang Ninh.

To complete the technical process of environmental sanitation in the concentrated shrimp farming areas in Tan An, Quang Ninh.

3. Objects and scopes of research

*Subjects:*Water environment (water supply, pond water, wastewater), sewage sludge (after the culture pond) and soil/sediment (in layers of 20-30 cm, 50-60 cm and 80-90 cm) in ponds in the concentrated shrimp farmings in Quang Ninh province.

Spatial scope: Water supply and soil/sediment in ponds in concentrated shrimp farming areas in Quang Ninh; Supply water, water in ponds, wastewater, and sludge after farming of concentrated shrimp farming areas in Tan An, Quang Yen, Quang Ninh.

Time range: 2014 - 2019.

4. Research content

Research on environmental quality changes in concentrated shrimp farming areas in Quang Ninh province. Supply water, water in ponds, wastewater and sludge after farming at concentrated shrimp farming areas in Tan An, Quang Yen, Quang Ninh.

Proposing solutions (management and techniques) to control environmental quality in the concentrated shrimp farming areas in Quang Ninh.

The technical process of environmental control for shrimp farming in Tan An, Quang Ninh province has been completed (through testing the selected solution for biological products suited for water treatment in shrimp ponds in the laboratory; The best of bio-CP application was

selected with the Environmental Control Technical Process for testing at production scale based on the model of “Shrimp farming with less water change” being applied in Tan An, Quang Ninh province.

5. Research Methods

Location selection; Collect and preserve samples (water, soil/sediment); Sample analysis (soil, water, sludge); Experimental layout method; Professional solution; Methods of evaluation and data processing; Expert consultation; Using and quoting data and information from documentation.

6. Scientific and practical significances of the thesis

Scientific significance: Determining environmental quality fluctuations in shrimp farming areas in Quang Ninh province (supply water, soil, pond water, wastewater and sludge); Proposing technical process for environmental control of shrimp farmings in Quang Ninh province.

Practical significance: Contributing to the completion of the EMS process of shrimp farming applied on the basis of the model "Shrimp farming with less water change"; Providing a part of the scientific basis for the revision and issuance of new Vietnam water quality standard related to shrimp farming and providing a reference for developing strategies and schemes on shrimp farming development.

7. New contributions of the thesis

(1) Results of systematic research on changes in environmental parameters (soil, water, sludge) in concentrated shrimp farming areas in Quang Ninh province.

(2) Provided a synthesized solution to control the environmental quality of shrimp farming areas in Quang Ninh province.

(3) Applied testing of technical solutions to select and use suitable probiotics for water treatment in shrimp ponds on the laboratory and production scale; thereby completing the technical process of environmental

sanitation in the concentrated shrimp farming areas in Tan An, Quang Ninh province, contributing to perfecting the model of "Shrimp farming with less water change".

CHAPTER 1. OVERVIEW OF CHANGES AND SOLUTIONS FOR CONTROL ENVIRONMENTAL QUALITY IN SHRIMP CULTURE AREAS

1.1. Studies on changes in water and soil quality in shrimp farming areas in some countries around the world and in Vietnam

1.1.1. Studies on changes in water and soil/sediment quality in shrimp farming areas in some countries around the world

In some countries such as India, Indonesia, the Philippines, Bangladesh, China, etc., where shrimp farming is developed, the study of fluctuations in water quality, sediment and its impact on shrimp growth and development are always concerned. The results shows that the values of the parameters of supply water, pond water, wastewater and soil/sediment are always concerned.

1.1.2. Studies on changes in water and soil/sediment quality in shrimp farming areas in Vietnam

Researches in Vietnam focus on specific groups of problems on water quality fluctuations, pond water, and wastewater, but very few studies have been conducted on changes in overall environmental quality or the water supply chain , pond water and wastewater after shrimp farming. However, studies have evaluated and identified a number of specific environmental parameters that exceed the permissible limits such as: NH_4^+, TSS, DO, COD, BOD_5, PO_4^{3-}... affecting aquatic environmental quality for shrimp culture [17], [20], [22], [31], [32], [33], [39].

1.2. Solutions for environmental control in shrimp farming areas

1.2.1. Research on solutions to control environmental quality in shrimp farming areas in some countries in the world

Management solutions : by promulgating and enforcing legal documents to manage and control the environmental quality of shrimp farming areas.

Technical solutions : applying technologies to treat and reuse shrimp farming wastewater; Using wetlands to treat contaminated waste; Using probiotics to treat shrimp pond waste; Apply Biofloc technology and Ozone aeration technology to treat water quality in ponds to protect the environment in shrimp farming areas.

1.2.2. Some studies on solutions to control the environment for shrimp farming in Vietnam

Management solutions: Develop and issue management documents; regularly carry out activities of monitoring and warning the quality of shrimp farming environment.

Technical solutions: Developing, implementing and applying the planning and infrastructure of farming areas; Use of probiotics; Control shrimp food intake; Waste treatment of shrimp ponds; Apply shrimp farming technology to reduce waste; Biofloc technology for shrimp farming; The 02, 03 stages of shrimp farming processes and the application of environmental control carrying out the model of "Shrimp farming with little water change".

1.3. Situation of shrimp farming development in Quang Ninh

1.3.1. Characteristics of weather and land

Quang Ninh has a tropical monsoon climate in the coastal area and has four distinct seasons. Salinity (S ‰): ranges from 5-35 ‰ , in the dry season (15-35 ‰) and low salinity in the rainy season (0 - 15); The average

annual temperature is 23 - 24^{o} C, low in winter (6-15^{o} C) and high in summer (37-40^{o}C). The average annual rainfall is nearly 2.000 mm, the highest is up to 2.600 mm. The rainy season is from May to October, focusing in July, August, and September. The average rainfall in the dry season is 1.500 mm.

About the land: Most of the shrimp farming areas are formerly mangrove land. The ground through the anaerobic process is shown by low ratio of iron 3 and iron 2 (Fe_2O_3/FeO), low nitrate content; toxic substances such as high H_2S, NH_3 .

1.3.2. Area and production of shrimp farming in the period of 2008-2018

Results showed that brackish water in shrimp farming aresa in Quang Ninh province continuously increased from 2008 (8,668 ha) to 2018 (10,821 ha). Comparing to 2008, the fastest expansion of shrimp farming areas were in 2011 (102.33%), 2017 (109.58%) and 2018 (106.56%) and the growth rate in shrimp farming areas from 2008 to 2018 were 124.84% (2,153 ha). Shrimp production from 2008 to 2018 increased by a significant number: 6,787 tons in 2008 to 13,193 tons in 2018; the growth rate from 2008 to 2018 in terms of output was 194.39%.1.3.3. Infrastructure, use of probiotics and aquatic veterinary drugs

(1) Infrastructure: Square-shaped ponds account for the highest level of 34.4%, the rest are rectangular, circular. Ponds are usually sloped towards the drain in the middle of the pond to facilitate water reversal, O_2 supply and solid waste collection (1) Equipment system: Hard ground pond with surrounding concrete embankment and tarpaulin pond. The device in the pond has a water wheel (80.3%) in combination with aeration of the pond bottom to increase O_2 content, discharge toxic gases and collect solid waste in the pond. (3) probiotics: is used in the rearing process to create

beneficial microorganisms in the aquatic environment, overwhelming harmful microorganisms in the pond. (4) Chemicals and veterinary drugs: many shrimp farms still use excessively, not following the manufacturer's instructions, causing residues and leading to soil and water pollution.

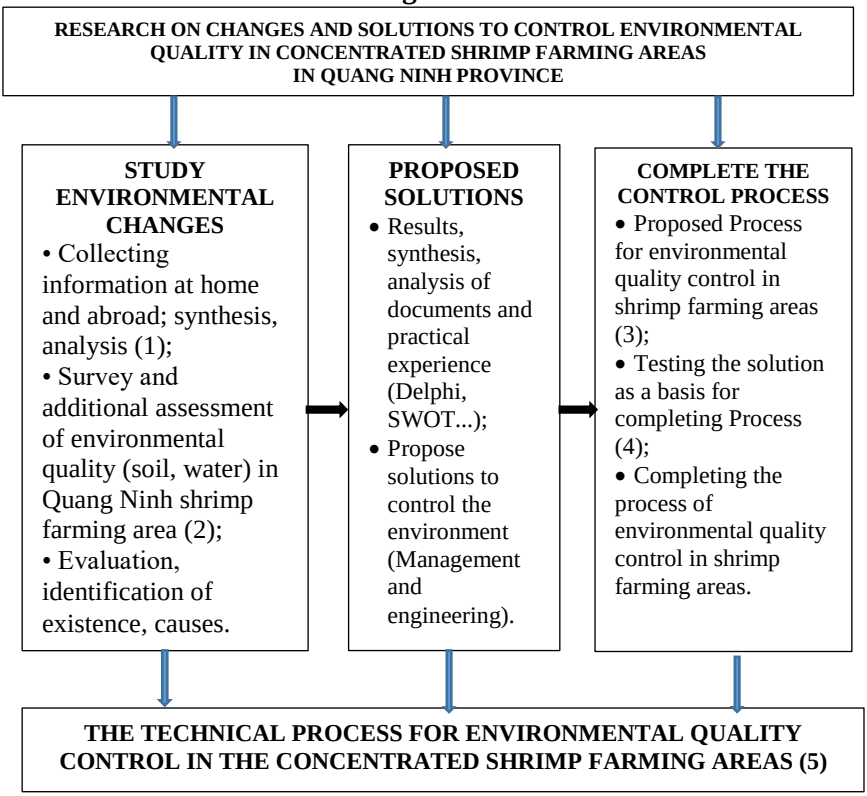
Conclusion of Chapter 1

Through the analysis and study of the above documents, some main results have been achieved and the shortcomings need to be resolved as follows: results on environmental fluctuations and environmental control solutions in concentrated shrimp farming areas in some countries in the world, in Vietnam and Quang Ninh province have focused on assessing the current status of water quality, part of the water in ponds and wastewater and proposing solutions (management and engineering). Control the quality of seed, feed, medicine, chemicals, probiotics, water supply, water in ponds, waste to the environment were also mentioned. However, most of the studies are fragmentary, difficult to inherit, lack of regularity and systematicity; and mainly focus on research on a number of problem groups or aspects to serve to increase productivity and quality of farmed shrimp, but not much attention is paid to environmental quality, disease prevention in shrimp farming. In particular, there are no solutions to control the overall environmental quality at each stage in the shrimp farming model.

Based on the above, the thesis will focus on studying the changes in overall environmental quality from the supply water, pond water, wastewater, sludge and soil in the concentrated shrimp farming areas, thereby offering solutions. Measures to control environmental quality in concentrated shrimp farming areas in Quang Ninh is carried out.

CHAPTER 2. RESEARCH METHODS

2.1. Dissertation research diagram



***Notes* :**

1) Information in Vietnam and other countries on changes in environmental quality (soil, water) in shrimp farming areas and solutions for environmental control of shrimp farming areas;

2) Environmental Quality of water supply; land in Quang Ninh; Quality of water supply, pond water, wastewater and sludge in Tan An, Quang Ninh;

3) Propose a process for environmental quality control in shrimp farming areas on the basis of selection and inheritance of relevant processes and technical guidelines.

4) Experiment: (1) The effectiveness of probiotics in reducing water pollution in shrimp ponds in the laboratory; (2) Using the selected probiotics along with the technical Process for quality control of shrimp farming areas (proposed), implemented on the model of "Shrimp farming with little water change" in Tan An, Quang Ninh.

5) The technical process of environmental control of the concentrated shrimp farming areas is completed on the basis of the proposed process (additional, new) after testing.

2.2. Research Methods

2.2.1. Selection a sampling location

2.2.1.1. Location of coastal water sample collection in Quang Ninh

Selection of sites in Ha Long, Cam Pha and Tien Yen of Quang Ninh province, concentrated farming areas, sampling period: 2014, 2016.

2.2.1.2. Location of soil sample collection in shrimp farming area in Quang Ninh

Concentrated shrimp farming areas of Tan An Seafood Joint Stock Company in Tan An ward, Quang Yen, Quang Ninh province. Analysis of some specific parameters of soil quality (pH, Nts, C-HCts, Pts, Fe (mobile) and Ndt); Sampling time was in August (end of shrimp farming) in 2014, 2016.

2.1.1.3. Sampling site for water supply, pond water, wastewater and sludge in shrimp farming areas in Tan An

Selected representatives of ponds of Tan An Seafood Joint Stock Company, Quang Ninh and chose 03 farming households with the same conditions and farming methods in Tan An.

2.2.2. Sample collection and preservation method

Sample collection, preservation and transportation were carried out according to the method according to current Vietnam standard

2.2.3. Sample analysis method

The determination of the parameters to be analyzed were based on the current Vietnam standard, the summary results of environmental quality monitoring in the shrimp farming areas after many years and the Delphi method to select and determine the parameters to be studied in order to ensure representativeness and science were done.

2.2.4. Experimental set-up method

2.2.4.1. Probiotics test reduces water pollution in shrimp ponds in the laboratory

Conducting a trial of 3 types of domestic probiotics commonly used by shrimp farmers in the northern coastal provinces: (1) Preparation A (CPA): *Bacillus subtilis* $3x10^{10}$ CFU/g; (2) Preparation B (CPB): *Bacillus subtilis* $2x10^{10}$ CFU/g; (3) Preparation C (CPC): *Bacillus subtilis* $2x10^{10}$ CFU/g.

The experiment was in 12 glass tanks with a capacity of 80 liters, divided into 4 lots. The glass tanks were together to supplement the source of cultured water, farmed shrimp, and seed; aeration mode and feed supply, feeding mode,. Water and shrimps were taken from the same pond in the 2nd month (shrimp were 45 days old). Each tank had 8 shrimp, equivalent to a density of 80 shrimp/m^3 (similar to the actual stocking

density).

Monitor and analyze factors: temperature, pH, salinity, DO, COD, N-NH_4^+, P-PO_4^{3-}, H_2S and measure shrimp size, weight and survival on days 5 and 15 of the experimental period. Experiment time: 10/2017.

2.2.4.2. Testing the environmental controlat the production scale

Implemented in 03 whiteleg shrimp ponds in the concentrated shrimp farming areas in Tan An with an area of about 4,000 m^2. Shrimp stocking density was pond 1: 25 shrimp/m^2; Pond 2: 35 shrimp/m^2 and pond 3: 45 shrimp/m^2.

Experimental conditions: The experimental ponds were reared according to the model of "Shrimp farming with less water change" at Tan An Seafood Joint Stock Company, supplemented with selected probiotics from the laboratory and the proposed EMS probiotics. Monitor and analyze: temperature, pH, salinity, clarity, DO, COD, N-NH_4^+, P-PO_4^{3-}, H_2S, BOD_5, N-NO_2^-. Checked aquatic plants, productivity, production of farmed shrimp and calculate economic efficiency. Trial period: Shrimp farming May - July 2018.

2.2.5. Expert method

2.2.5.1. Delphi method for selecting environment parameters

The thesis consulted 30 experts to choose environmental quality monitoring parameters (pond supply water, pond water, wastewater, mud and soil/sediment). Basis for selecting criteria: Gather consensus opinion of experts >75%.

2.2.5.2. The SWOT method proposes and selects solutions

On the basis of results, thesis summarized and analyzed strengths, weaknesses, opportunities and challenges; thereby proposing some solutions to control the environment in concentrated shrimp farming areas.

2.2.5.3. Building and completing the technical process of environmental quality control

The above model of "Shrimp farming with little water change" was being widely applied in the concentrated shrimp farming areas in Quang Ninh, applying the technical process of environmental sanitation. The thesis inherited this process and, through the experimental results, along with the application of expert methods, supplemented and refreshed some stages in the technical process of environmental sanitation in the concentrated shrimp farming areas in Tan An, Quang Ninh.

2.2.6. Methods of evaluating and processing data

Determination of some biological parameters of shrimp (length, weight and survival rate...) according to the regulations of the industry .

Evaluation of parameters according to QCVN 02-19:2014/BNNPTNT

on brackish water shrimp farming establishments - conditions to ensure veterinary hygiene, environmental protection and food safety; QCVN 08-MT:2015/BTNMT on surface water quality; QCVN 10-MT:2015/BTNMT assesses coastal water quality for aquaculture.

Assess the self-cleaning capacity (D%) of the environment.

Collected samples, determine composition and quantity of unicellular algae in shrimp ponds according to Circular No. 24/2017/TT-BTNMT.

Determined the water quality index WQI by Entropy (WQI_E) according to the study of the US National Sanitation Foundation (NSF), the formula is as follows:

$$\mathrm{WQI} = \sum_{j=1}^{n} w_j . q_j \qquad [2.10]$$

In there:

+ q_j is the sub-index of parameter j determined by the formula:

$$q_j = \frac{c_j}{s_j}.100$$

+ Cj is the measured concentration of parameter j (DO, BOD_5, $N\text{-}NH_4^+$, $P\text{-}PO_4^{3-}$, COD);

+ Sj is the limit of parameter j with corresponding QVCNs (Limits of parameters are applied according to QCVN 08-MT:2015/BTNMT and QCVN 10-MT:2015/BTNMT).

Determined w_j according to Ding SF and Shi ZZ, J (2005) [68], Li *et al*., (2010) [82].

- w_j is the weight of parameter j determined by the formula:

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n}(1 - e_j)}$$

Here e_j is the entropy parameter of the j parameters through the formula:

$$e_j = -\frac{1}{\ln(m)} \sum_{i=1}^{m} P_{ij} . \ln(P_{ij}),\ P_{ij} = \frac{1+y_{ij}}{\sum_{i=1}^{m}(1+y_{ij})}$$

The parameter y_{ij} is formed from normalizing the matrix with i= 1,2,3,..,m monitoring points and j=1,2,3,..,n parameters; p_{ij} ranges from 0-1. y_{ij} is determined by the following two formulas:

The positive parameter (the larger the value, the better the quality (DO)), y_{ij} is determined as follows:

$$y_{ij} = \frac{x_{ij} - (x_{ij})_{min}}{(x_{ij})_{max} - (x_{ij})_{min}}$$

Negative parameter (the larger the parameter value, the more pollution (nutrition, microbiology), y_{ij} is determined as follows:

$$y_{ij} = \frac{x_{max} - x_{ij}}{(x_{ij})_{max} - (x_{ij})_{min}}$$

Entropy weighted water quality index classification scale WQI_E according to 5 water quality levels is shown in Table 2.6 [70], [82], [95]. [103].

Table 2.6. Weighted Entropy Classification Scale (WQI_E)

STT	WQI_E	Water quality
first	< 50	Very good
2	50 - <100	Good
3	100 - <150	Medium
4	150 - <200	Least
5	≥200	Very poor

The data were processed using the MS Excel 2010 application.

2.2.7. User documentation

Synthesized results from topics, projects, , reports and topics from management agencies at all levels and models of shrimp farming with little water change.

CHAPTER 3. RESEARCH RESULTS AND DISCUSSION

3.1. Assessment of environmental quality changes in concentrated shrimp farming areas in Quang Ninh

3.1.1. Changes in water quality for shrimp farming

The environmental quality of water sources in concentrated shrimp farming areas across the country in the period 2009 - 2018 showed that only local pollution occured in the supply water. Assess the variation in water quality for some concentrated shrimp farming areas in Quang Ninh: Tien Yen (TY), Cam Pha (CP) and Ha Long (HL) in 2014 and 2016, was through fluctuations in COD and BOD_5 and changes in $N\text{-}NH_4^+$ and $P\text{-}PO_4^{3-}$ content. They indicated that water quality in coastal areas was showing signs of nutrient salt pollution, especially in the rainy season. signs of euthanasia. The results of water quality in Quang Ninh in 2014, 2016 by the Entropy method (WQI_E) were shown in Table 3.2.

Table 3.2. Value of WQI_E index of shrimp farming water in Quang Ninh

Farming Area/water quality level		Small Est value	The Greatest value	The average value		
				Average value in 2014 and 2016	Year 2014	2016
Cam Pha	Value	43.0	135.9	76.0 ± *30.7*	74.1 ± *29.1*	77.8 ± *33.5*
	Quality	Very good	Medium	Good	Good	Good
Ha Long	Value	32.6	139.9	75.4 ± *36.6*	70.4 ± *34.9*	80.5 ± *39.0*
	Quality	Very good	Medium	Good	Good	Good
Tien Yen	Value	32.5	107.3	64.0 ± *26.0*	60.6 ± *26.0*	67.4 ± *26.6*
	Quality	Very good	Medium	Good	Good	Good

3.1.2. Environmental changes in shrimp pond soil

The results of the study on changes in the quality of shrimp pond soil over the time showed that the soil tended to be polluted after many years of monoculture shrimp farming, especially in the topsoil (20-30 cm),. Specific results were shown in Table 3.3. a, b and c.

Table 3.3a. Changes in the quality of soil layers in shrimp ponds in 2008 in Tan An, Quang Ninh

Year of sampling / Year of farming	Parameter					
	pH	N_{TS}	C-HC $_{ts}$	P $_{ts}$	Fe $_{dd}$	N $_{dt}$
Raised since 2002						
20-30 cm	**7.00**	**0.13**	**2.06**	**13.95**	**16.15**	**3.33**
50-60 cm	4.68	0.11	2.15	7.29	17.20	2.98
80-90 cm	5.12	0.09	2.13	6.39	22.80	2.98
Raised since 2004						
20-30 cm	**5.80**	**0.12**	**2.02**	**12.80**	**15.50**	**2.54**
50-60 cm	5.40	0.10	2.01	7.15	16.70	3.33
80-90 cm	5.05	0.08	1.94	6.05	16.26	2.50
Raised since 2006						
20-30 cm	**5.88**	**0.09**	**1.96**	**11.15**	**15.11**	**2.28**
50-60 cm	4.79	0.10	1.93	6.90	15.70	2.15
80-90 cm	4.41	0.07	1.84	6.69	15.50	2.03

Table 3.3b. Changes in the quality of soil layers in shrimp ponds in 2014 in Tan An, Quang Ninh

Year of sampling / Year of farming	Parameter					
	pH	N ts	C-HC ts	P ts	Fe dd	N dt
Raised since 2002						
20-30 cm	**6.28**	**0.29**	**2.36**	**26.18**	**16.12**	**4.54**
50-60 cm	4.65	0.10	2.10	7.23	17.20	2.91
80-90 cm	5.47	0.08	2.11	6.22	17.11	2.78
Raised since 2004						
20-30 cm	**7.19**	**0.23**	**2.13**	**19.33**	**15.90**	**4.26**
50-60 cm	5.52	0.09	1.88	6.70	15.80	3.33
80-90 cm	5.43	0.09	1.84	6.55	15.26	2.20
Raised since 2006						
20-30 cm	**6.28**	**0.22**	**2.10**	**17.30**	**15.61**	**4.11**
50-60 cm	5.44	0.10	1.89	6.70	15.70	2.85
80-90 cm	5.37	0.08	1.74	6.49	17.50	2.33

Table 3.3c. Changes in the quality of soil layers in shrimp ponds in 2016 in Tan An, Quang Ninh

Year of sampling / Year of farming	Parameter					
	pH	N_{TS}	C-HC_{ts}	P_{ts}	Fe_{dd}	N_{dt}
Raised since 2002						
20-30 cm	**7.37**	**0.34**	**2.43**	**29.32**	**17.02**	**4.62**
50-60 cm	5.96	0.11	2.25	7.19	17.21	2.91
80-90 cm	5.48	0.11	2.10	6.29	22.33	2.82
Raised since 2004						
20-30 cm	**6.99**	**0.25**	**2.34**	**23.78**	**17.01**	**3.95**
50-60 cm	5.90	0.13	2.11	7.12	16.22	3.03
80-90 cm	5.16	0.09	1.97	6.15	16.00	2.56
Raised since 2006						
20-30 cm	**7.62**	**0.24**	**2.22**	**22.21**	**15.47**	**3.67**
50-60 cm	5.90	0.09	1.92	6.89	15.10	2.89
80-90 cm	4.61	0.08	1.86	6.58	15.11	2.43

3.1.3. Changes in environmental quality of shrimp farming in Tan An , Quang Ninh province

3.1.3.1. Changes in water quality for shrimp farming in Tan An

The results of monitoring water environment: pH, salinity, TSS, DO, COD, N-NH_4^+, P-PO_4^{3} in 3 shrimp farming seasons in 2008, 2014 and 2016 showed the quality of the water source. Levels tended to decline beyond the permissible limits according to the season, the time between the years of farming and the farming season. Specific results were in Table 3.4.

Table 3.4. Changes in some water environment parameters at Tan An concentrated shrimp farming areas

Parameter	2008		2014		2016		Value range		QCVN 10-MT/2015/ BTNMT
	K	M	K	M	K	M	K	M	
pH	7,5	7,7	7,2	7,6	7,3	7,5	7,2 - 7,5	7,2 - 7,7	6,5 - 8,5
S‰ (*ppt*)	13	8,5	16	7,5	13,8	9,6	13 - 16	8,5 - 9,6	7 -25
TSS (*NTU*)	32	58	39	58	42	57,5	32 - 39	57,5 - 58	
DO (*mg/l*)	5,2	4,5	4,8	4,8	4,8	4,5	4,8 - 5,2	4,5 - 4,8	≥ 5
COD (*mg/l*)	21	1,6	2,8	21	23	18	2,8 - 2,3	3,6 - 5,1	10 (*)
N-NH_4^+(*mg/l*)	0,05	0,30	0,08	0,33	0.07	0.40	0.05 - 0.08	0.3 - 0.4	0.1
P-PO_4^{3-} (*mg/l*	0.06	0.15	0.08	0.12	0.12	0.20	0.06 - 0.12	0.12 - 0.2	0.2

*Note: * K: Dry season (May and May, shrimp farming), M: Rainy season (May and June, shrimp farming) (*) According to QCVN 08-MT:2015/BTNMT: National regulation on surface water quality.*

Through the results of calculating the pollution level of water quality supplied to shrimp ponds in Tan An, based on the method of determining the WQI water quality index by the Entropy method were to evaluate the quality of water supplied to some farming areas. Shrimp in Quang Ninh province clearly showed an increase in pollution during the rainy season months and gradually increased over the study period, especially in 2008, 2014 and 2016.

3.1.3.2. Water quality fluctuations in shrimp ponds in Tan An

Table 3.7. Changes in some water parameters in concentrated shrimp ponds in Tan An, Quang Ninh in 2008, 2014, 2016

Parameter	2008		2014		2016		Value range		QCVN 02-19:2014/BNNPTNT
	K	M	K	M	K	M	K	M	
Temperature	22,5	35,5	28	36,5	25,5	38	22,5 - 28	35 - 38	18 - 33
pH	7,5	7,8	7,9	7,7	7,7	7,7	7,5 - 7,7	7,7 - 7,8	7- 9
S (‰)	15,5	10,7	13,8	9,6	15,5	10,8	13,8 - 15,5	10,7 - 13,8	5 - 35
DO (mg/l)	4,5	4,1	5,0	4,2	4,8	5,1	4,5 - 5	4,1 - 5,1	≥ 3,5
COD (mg/l)	16,0	23,0	12,5	16,1	10,0	14,0	10 - 16	14 - 23	< 20 (*)
$N\text{-}NH_4^+$ (mg/l)	0,19	0,58	017	0,52	0,15	0,52	0,15 - 0,19	0,52 - 0,58	0,1 (*)
$P\text{-}PO_4^3$ (mg/l)	0,15	0,18	0,19	0,24	0,22	0,23	0,15 - 0,22	0,18 - 0,24	0,2 (*)
H_2S	0,010	0,015	0,011	0,022	0,020	0,016	0,01 - 0,02	0,015 - 0,02	< 0,05

Note: K: Dry season (April and May of shrimp farming), M: Rainy season (June and July of shrimp farming). 3 samples/month is taken each month, the range of values in the dry season is calculated with n = 18, in the rainy season n = 18 according to 2008, 2014, 2016.

The results of the above study were different from the results of analysis from 2015 to 2019 of the Directorate of Fisheries. Water in shrimp ponds had a high rate of exceeding the threshold, COD (37.2%), $N\text{-}NH_4^+$ (13.2%), H_2S (8.3%).

3.1.3.3. Wastewater from shrimp ponds in Tan An

The results of wastewater research in the concentrated shrimp farming area in Tan An showed that wastewater had a suspended solids (TSS) content from 12 mg/l at the beginning of the shrimp farming to 70 mg/l at the end of the farming, with high organic matter content. BOD_5 was from 7 mg/l to 35 mg/l; COD was from 13 mg/l to - 50 mg/l; $N\text{-}NH_4^+$ was from 0.2 mg/l to 1 mg/l.

Table 3.9. Characteristics of some parameters of pond bottom wastewater according to the shrimp culture cycle in the beginning and the end of the shrimp farming season in 2008, 2014, 2016

Time / Parameter	2008			Year 2014			2016		
	The beginning of the service	End of service	Average	The beginning of the service	End of cycle	Average	The beginning of the service	End of cycle	Average
TSS	15	70	42.5	12	66	39.0	13	56	34.5
BOD_5	17	35	26.0	10	33	21.5	7	29	18
COD	23	50	36,5	15	48	31,5	13	44	28,5
$N\text{-}NH_4^+$	0,4	1,0	0,70	0,3	0,9	0,60	0,2	0,8	0,48

Results of wastewater at the end of the harvest season, wastewater for cleaning ponds at the end of the farming season

Wastewater properties through parameters TSS, BOD, COD, $N\text{-}NH_4^+$, total Nitrogen (N_{ts}) and total Phosphorus (P_{ts}) from shrimp ponds in the farming seasons 2008, 2014 and 2016 were shown in Table 3.12. Table showed that both types of shrimp wastewater were highly polluted, compared to column B, QCVN 40:2011/ BTNMT.

Table 3.10. Results of pond water discharge and pond sanitation wastewater at the end of the shrimp farming season

N_o	Parameter	Result		QCVN 40:2011/BTNMT (Column B)
		(1)	(2)	
1	TSS	48.5 - 185	825 - 1225	100
2	BOD	45 - 185	735 - 1250	50
3	COD	65 - 225	975 - 1625	150
4	$N\text{-}NH_4^+$	5 - 7	18.2 - 45	ten
5	Total Nitrogen (N_{ts})	10 - 18.2	45 - 60.5	40
6	Total Phosphorus (P_{ts})	1 - 5	21 - 35.5	6

Notes: (1) The pond water is discharged at the end of the harvest season; (2) Sanitary wastewater at the end of the farming season.

Results on environmental changes in supply water, pond water and wastewater in shrimp ponds in Tan An: some specific parameters and indicators of pollution in concentrated shrimp farming were identified. However, in order to have more scientific basis, an additional assessment of changes in water environment in ponds and sludge of 03 shrimp farming households in 2018 and 2019 were conducted in Tan An to compare with the results of the study in 2008, 2014 and 2016.

3.1.3.4. Quality of water in ponds and sludge of households in Tan An

Water quality in shrimp ponds: The results of monitoring shrimp pond samples of 03 households in Tan An, Quang Ninh in the 2018 farming showed that: through 8 parameters of water quality monitoring in the pond (T^0C water, salinity, pH, COD, $N\text{-}NH_3$, H_2S, $N\text{-}NH_4^+$ and DO) (according to QCVN 02-19:2014/BNNPTNT). Fluctuations in water quality of all 3 ponds showed the trend of pollution over time of shrimp culture (COD, H_2S, $N\text{-}NH_4^+$ and DO values).

Quality of sludge in shrimp farming households: The results of assessing the changes in the quality of pond sludge immediately after dredging and after 5 months showed that there was not much difference in the characteristics of pond sludge between the 3 shrimp farming households. EC, N_{dt} and P_{dt} and heavy metals (As, Cd, Pb and Cu) in pond sludge decreased after 5 months of dredging. Particularly, the sludge pH value was unchanged over time.

3.2. Solutions to control environmental quality in concentrated shrimp farming areas in Quang Ninh

3.2.1. Management solution

3.2.1.1. Environmental monitoring

Review the parameters to be monitored, identify the core elements required; which clearly states the parameters that need to be monitored regularly, seasonally and irregularly. Clearly identify the advantages,

disadvantages and approaches of monitoring and warning methods: applying remote sensing technology, automatic monitoring to serve environmental and disease warnings for shrimp farming.

3.2.1.2. Policy mechanisms

Create an open mechanism to attract domestic and foreign investors to participate in building a water supply system to provide clean water for farming areas, wastewater treatment system: Exemption from land tax, import tax on equipment, supporting the policy of producing input aquatic materials.

3.2.1.3. Science and Technology

Research to identify/identify emission sources that directly and indirectly affect water quality in concentrated shrimp farming areas and propose control measures. Standardize the type, quality and quantity of probiotics used in the shrimp pond system in accordance with the conditions of the farming area.

3.2.1.4. Building and completing the technical process of environmental quality control

Completing the technical process of environmental control in the model of "Shrimp farming with little water change".

3.2.2. Technical solution

3.2.2.1. Infrastructure and equipment for concentrated shrimp farming

The infrastructure of the shrimp farming area includes (1) Irrigation infrastructure consisting of 3 main stages: the upstream water supply system, the pond system and the wastewater treatment system. (2) The infrastructure in the concentrated farming area includes a clean water supply system, shrimp pond area and wastewater treatment system.

Equipment and tools: Transport vehicles, pond improvement machinery and water supply pumps; equipment to provide O_2 and collect solid waste; equipment, machinery for environmental testing, biology and specialized tools for environmental treatment.

3.2.2.2. Controlling water quality during shrimp farming

Improve the technique of treating water sources to meet quality standards; Stabilize water quality during rearing; Wastewater treatment techniques before being discharged into the environment and the process of using probiotic

3.3. Technical process of environmental sanitation in concentrated shrimp farming areas in Tan An, Quang Ninh

Applying technical solutions on the use of suitable probiotics in shrimp pond water treatment on the model of "Shrimp farming with less water change" in Tan An, Quang Ninh.

3.3.1. Experimenting with the solution of using probiotics to treat shrimp pond water in the laboratory

In order to confirm the role and effectiveness of probiotics in water treatment in ponds, the thesis has tested 03 types of bio- CPs in laboratory conditions (according to commonly used survey results) with different sources. Water was taken from shrimp ponds in the 3rd month(month with low environmental quality). The results showed that: the effective treatment of water in shrimp ponds with CPB was effective for $N\text{-}NH_4^+$ content within the permissible limit of 0.3 mg/l. The content of $P\text{-}PO_4^{3-}$ was with the highest treatment efficiency reached 71.8% and the survival rate of shrimp reached 96.3% (03 types of experimental preparations CPA, CPB, CPC).

3.3.2. Testing the technical process of environmental sanitation at production scale in Tan An , Quang Ninh province

On the basis of the "Shrimp farming with less water change" in Tan An and the obtained research results, new technical measures were selected and applied to complete the technical process of environmental pollution control.. The results showed that the improvement process was very positive, healthy shrimp, no signs of disease and high yield. probiotics tested in shrimp ponds had good effects in reducing environmental

pollution.

3.3.3. Technical process of environmental control of shrimp farming area in Tan An

The results applied in production to perfect the technical process of environmental control of shrimp farming area (additional and new process) were shown in Table 3.19.

Table 3.19. Comparative results of the existing environmental control technical process and the completed process applied to the model "Shrimp farming with little water change" in Tan An, Quang Ninh

N_0	Process content	Procedure	Process improvement (additional, new)
1	**Infrastructure, equipment, seed, food**		
1.1	Site layout of farming area system	Had	More detailed, specific and reasonable
1.2	System of equipment for environmental control	Had	More detailed, specific and reasonable
1.3	Breeds and food	Had	Select good varieties, nurse, tame up to P_{20} ; Check food quality, control leftovers; Quality control of other inputs.
1.4	Shrimp pond bottom	Ground floor, concrete embankment	*New;* The bottom floor is lined with canvas so as not to affect the environment from the pond bottom.
1.5	Shrimp farmers		Need to be equipped with environmental control
2	**Controlling water supply**		
2.1	Sedimentation reservoir	Had	More details on how to make water not stagnant
2.2	Water treatment pond		
-	Kill pathogens with chlorine or chemicals	Had	Be more specific and do not use chemicals
-	Supplements with probiotics		*New*
2.3	Supply water to the pond	Had	More detailed, specific and reasonable
3	**Controlling water quality in shrimp ponds**		
3.1	pond waste	Had	More specifically about the dosage of lime, without using chemicals
3.2	Water supply for ponds	Had	More specific; should initially supply 70 cm, then gradually raise the water level

			in the pond.
3.3	Fertilizer formula causes algae color	Had	*New*; There is a specific fertilizer formula
3.4	Water, oxygen supply and solid waste collection		
-	Use a fan	Had	More specific about the additional time
-	Using an aerator		*New;* Use an air compressor to provide oxygen to the bottom layer
-	Operation mode of the water-aeration system		*New;* when to 100% turn the water, when to use mixed water
3.5	Maintain pond water color throughout the culture cycle	Had	More specific about the measure
3.6	Water replenishment and water change mode	Had	Add water 15-20 cm/week until the pond water depth is sufficient; Daily rehydration for evaporation and solid waste discharge; Change water periodically of the culture cycle, increasing gradually towards the end of the farming.
3.7	Solid waste collection	Had	More specific
3.8	Using probiotics	Had	*New;* be more specific about the type and additional time to stabilize the shrimp pond environment.
3.9	Check the quality of the environment during the rearing process	Had	*Specifically, the parameters to be monitored:* Daily: t ^{o} C, pH O_2 , TSS, water color, taste...; Weekly: S^{o}/oo, COD, BOD_5 , NH_4^+ , PO_4^{3-} and H_2S...
4	**Wastewater treatment and reuse**		
4.1	Type of solid waste	Had	More specifically about time and measures: Turning water to put solid waste into the settling pit in the middle of the pond; Siphon solid waste periodically, increasing gradually in the last month; Shrimp is grown in cages in the middle of the pond to consume solid waste.
4.2	Water treatment after solid waste removal		*New*, use probiotics to process
4.3	Reuse water when needed	Had	More specific

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSION

1.1. Changes in environmental quality of water supply, soil/sediment, pond water, wastewater and sludge in some concentrated shrimp farming areas were assessed:

- The quality of the water supply had a clear variation between the months of the dry season and the rainy season; in the rainy season months, the quality of the environment fell below the allowable threshold; emission sources were mainly from leaching (organic humus, agricultural and industrial activities...) and flood and rain from rivers in June, 7, 8, and 9 of the year;

- Environment of Pond soil/sediment tended to accumulate pollutants after many years of monoculture shrimp farming, especially in the topsoil layer (20-30 cm), which was evident in the parameters Pts, Nts, NH_4^+; at floors 50 - 60 cm, 80 - 90 cm had fluctuations but low levels;

- The quality of water in the ponds fluctuated greatly in the last months of the culture cycle (3rd and 4th month of culture); mainly organic and nutritional pollution. The main source of emissions was leftover food and animal waste. It showed that farming facilities with good infrastructure, compliance with the rearing process, environmental control, seed and feed had a good environmental quality

- Wastewater from ponds fluctuated over time in each shrimp culture cycle, increasing gradually from month 1 to month 2, 3, and 4. Pollution of pond waste had a relationship with high or low stocking density, quality of feed and number of years of intensive shrimp culture in a fixed pond;

- Sewage sludge immediately after dredging and pond sludge after 5 months of dredging from shrimp ponds showed that EC, Ndt and Pdt parameters and heavy metals (As, Cd, Pb and Cu) in the pond sludge decreased gradually. In the condition of storing sludge after 5 months, the amount of easily digestible Nitrogen and Phosphorus were still quite high, the heavy metals content was low, the salinity reduced, it was possible to use the sludge as a material for composting or planting trees.

1.2. So far, the solutions to reduce environmental pollution in the farming area had many shortcomings from the management and technical stages, there wasno basic solution and the technical process to control the quality of the shrimp farming area effectively. Therefore, through the SWOT analysis tool was a basis to propose solutions to control the environment in the concentrated shrimp farming area suitable to the conditions for shrimp farming activities; The focus was on management solutions (environmental monitoring, mechanisms and policies, science and technology and building and perfecting the environmental control process) and technical solutions (upgrading infrastructure, equipping and controlling facilities) water quality control in shrimp farming).

1.3. The technical process of environmental control was completed through implementation: *Experiment in the laboratory*: Technical solutions for the efficiency of using 03 types of bio-CPs produced in the country, which are widely used. The results showed that there was a marked reduction in environmental pollution in shrimp ponds. In particular, CPB probiotics showed higher treatment efficiency. *Experiment at production scale*: Applying CPB probiotics together with the Technical Process of environmental control to use for testing with an area of 4,000 m2 shrimp ponds on the basis of the "Shrimp culture with little water change" model in Tan An, Quang Ninh gave good results. On that basis, it was possible to supplement and complete the Environmental Control Technical Process (additional, new) so that it could be widely applied in Quang Ninh province and neighboring provinces.

2. RECOMMENDATIONS

2.1. Suggesting management agencies at all levels to consider applying the technical process for environmental quality control in concentrated shrimp farming areas in different shrimp farming models in the northern coastal provinces.

2.2. Using the results of the thesis as a reference for the development of strategies, planning and schemes for shrimp farming development.

LIST OF PUBLICATIONS

[1]. Nguyen Tien Long, Dinh Vu Thanh (2018), Evolution of soil environment quality in white shrimp ponds (*Penaeus vannamei*) concentrated in Quang Ninh province, *Journal of Agriculture & Rural Development - Part* 2 -June 2018, page 70 - 77.

[2]. Nguyen Tien Long, Tran Quang Thu (2018), Research on selection of probiotics to treat concentrated shrimp farming water, *Journal of Agriculture & Rural Development* , December 2018, pp. 188 - 194.

[3]. Nguyen Tien Long (2020), Assessment of the current status and environmental changes in the concentrated shrimp farming area along the coast of Vietnam, *Journal of Agriculture & Rural Development* , February 2020, pp. 73 - 81.