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Establish a Mathematical Model for Key Nutrients in Catfish Ponds

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Abstract: Catfish (Pangasius) is a famous and popular food in many countries around the world, and it has contributed greatly to the economy through exports. However, Pangasius farming without planning leads the fish to be more susceptible to disease and causing high pollution to the environment. The objective of this study is to use the mathematic model to identify the development processes of key nutrients in the catfish ponds. The model was used data from Washington lake and calibration and validation by measured data at the Vietnamese pond. The results showed that the actual PO_4^{3-} was in the range of 0.043 - 3.07 mg/l, PO_4^{3-} modeling in range of 0.043 to 1.956 mg/L; TP actual: 0.098 – 3.924 mg/L, TP modeling: 0.098 – 2.658 mg/L with an average error of the PO_4^{3-} and TP at the modeling graphs were 40% and 30.83%. The actual NO_3^- concentration: 0.018 - 0.8, modeling NO_3^-: 0.018 - 0.832 mg/L; actual NH_4^+: 0.146 – 2.83 mg/L, NH_4^+ modeling: 0.146 – 3.432 mg/L; actual TN: 0.442 - 5.55 mg/L, TN modeling: 0.442 - 5.852 mg/L, the average error of NO_3^-, NH_4^+ and TN at the modeling graphs were 40.31%, 27.47% and 17.74%. The MSE and RMSE of of PO_4^{3-} in actual are 0.159 and 0.399 and in model are 0.000 and 0.016; TP in actual are 0.138 and 0.371 and in model are 0.000 and 0.003; NO_3^- in actual are 0.043 and 0.206 and in model are 0.000 and 0.000; NH_4^+ in actual are 1.343 and 1.159 and in model are 0.005 and 0.072; TN in actual are 0.195 and 0.441, in model are 0.001 and 0.031, respectively. The result of modeled data was still in the range of environmental indicators was mentioned in much other research. It helps to control the development of environmental factors in the pond to optimize the fish production as well as reduce the impact to the received areas. The model need to be continuing research to identify the impact of external factors (weather, light, etc.,) and also reduce the errors for better management.

Keywords: Pangasius, Modeling, Phosphorous, Nitrogen

1. Introduction

Pangasius farming in Vietnam is highly effective and has great potential for development. However, aquacultural activities have generated sources of solid waste, liquid waste, and emissions causing environmental pollution with the main sources of waste, including sludge during pangasius farming process containing surplus food sources, excess decomposition, chemicals, antibiotics, minerals diatomite, dolomite, sulfur deposition, toxic substances contained in alum soil Fe^{2+}, Fe^{3+}, Al^{3+}, SO_4^{2-}. Wastewater from aquaculture also contains the components of BOD_5 50 mg/L, COD 112 mg/L, Total Nitrogen (TN) 4.81 mg/L, Total Phosphorous (TP) 2.17 mg/L which can cause environmental pollution which needs to be thoroughly treated before being discharged into reception sources [1].

According to Duong Nhut Long [2] suitable Dissolved Oxygen (DO) concentration for intensive fish ponds is 3.5 – 6.5 mg/L. The lower oxygen threshold of Pangasius is less than 2.0 mg/L [3]. When raising fish at high densities, ponds often have local hypoxia syndrome due to the increase in CO_2 content in the water, decreased pH, increased N-NO_2 and fluctuations of some other environmental factors [4]. The average DO was ranged from 4.0 to 5.1 mg/L, while the lowest was 1.10 mg/L [5]. Total ammonium protein includes NH_3 and N-NH_4, where N-NH_4 is the nitrogen fertilizer necessary for plant growth, which promotes the algae growth in ponds. Ammonium protein is also generated in water due to the decomposition of organic compounds containing nitrogen (protein). TAN of intensive catfish ponds is 5 times higher than that of intensive shrimp ponds and 10 times higher than that of conventional aquaculture ponds [6]. According to Boyd [7], nitrate is a non-toxic form of protein, but with too high concentration it is also not beneficial for fish and shrimp, when high nitrate concentration in the water will cause algae to overgrow. In catfish ponds $N\text{-}NO_3$ ranges from 1.1-1.4 mg/L [5]. According to Boyd [8], the appropriate $P\text{-}PO_4$ content for fish ponds ranged from 0.005 – 0.2 mg/L (5 – 200 µg/L), when $P\text{-}PO_4$ < 5 µg/L algae stopped growing; $P\text{-}PO_4$ > 200 µg/L algae tend to bloom. Phosphorus is the limiting element for phytoplankton development [8]. According to Le Bao Ngoc [9] for intensive ponds, the content of soluble phosphorus reaches 0.44 ± 0.52 mg/L. The average concentration of $P\text{-}PO_4$ in intensive catfish ponds ranged from 0.492 to 0.775 mg/L, of which the average fluctuation through sampling in pond 1 was 0.492 ± 0.436 mg/L, pond 2 was 0.758 ± 0.610 mg/L and pond 3 is 0.528 ± 0.441 mg/L [5].

To study the effects of nutrients on the growth of Nile tilapia, Li et al. [10] developed a model using STELLA II software which is a field experiment that was designed to determine limiting nutritional factors for fish growth in fertilized ponds. Simulation results show that supplementary feeding compensates for natural food nutrient deficiencies. Results also reveal that protein supplements are necessary for increasing fish yields of fertilized ponds. Comparison of the data from simulation and observation indicates that the simulation values have a close correspondence with observed data, and the model is able to capture essential food nutrient dynamics in semi-intensive aquaculture ponds. Up to now, there are no studies on establishing models to determine the content of nutrients in catfish ponds in Vietnam.

Therefore, the objective of this study is to set up a mathematical model to simulate the change of the composition of major nutrients (DO, N, P) in Pangasius ponds to determine the maximum culture regime and help improve fish quality and minimize environmental impact.

2. Material and Method

2.1. Data Collection

Data were collected and analyzed in four striped catfish ponds with an average area of 200 m^2 for each and 2.5 m deep at Cai Rang District, Can Tho city. Water was exchanged every day by about 30% each time by pumping from the sedimentation pond (3,000 m^2).

Samples were collected at the same point under the feeding bridge where fish were fed at every time. DO were directly measured at the ponds every day (at 8 am and 4 pm) by HANNA analyzer. Samples of other factors such as TAN (Total Ammonium Nitrogen), $P\text{-}PO_4^{3-}$, TKN (Total Kjeldahl Nitrogen), TP, $N\text{-}NO_2^-$, $N\text{-}NO_3^-$ were collected before raising (L1) and every ten days in the morning time (total 13 times) from May to November 2016. Water was analyzed at Water Quality Laboratory – College of Aquaculture and Fisheries, Can Tho University. Sample reserve and analysis method followed the instruction and standard [11].

2.2. Data Processing Method

Data was collected from the *Pangasius* pond in the field and previous study. The mathematical model was used to simulate processes occurring in *Pangasius* ponds. Differential equations cannot be solved by conventional analytical methods but must be approximated by numerical methods as Runge-Kutta due to highly accurate, simple algorithm. The equations were solved numerically and then coded by Matlab 2018. The final step was used data sets and results from experiments or in previous studies to validate the model.

2.3. Model Assumption

The object of the study is a close pond for intensive catfish farming in the Mekong Delta of Vietnam, which has a simple physical structure that only represents the epilimnion pond. Nutritional resources for Pangasius fish was originated from autotrophic and heterotrophic food sources in ponds. The protein concentration of phytoplankton is assumed to be a constant. Water was exchanged 30% every day from the sedimentation pond with assuming there is no loss of water for leakage, evaporation. There is no exchange of heat and light at the water surface in the pond. The survival rate of fish is constant, and catfish ponds are homogeneous block.

2.4. Correlation Establishing

To establish the equations, it is necessary to understand the relationships of the components in the lake, the interactions and their interactions.

Based on the research of the relationship between C, P and N cycles; primary, secondary, tertiary production processes, the qualitative matrix was established for showing the relationship between the variables in the *Pangasius* ponds.

The matrix of mutual affecting factors in the *Pangasius* farming pond is set as in Table 1.

Base on the matrix of mutual affecting factors, the structure diagram of modeling which presents the correlation of environmental factors in pangasius ponds was set up as presented in Figure 1.

This model will be used to test the different alternative management options, simulation of components in pond (such as C, N, P, O), phytoplankton growth (diatoms, green algae, and blue algae), and zooplankton (copepods and cladocerans). These are considered to be very important groups to the development of catfish and the effects of autotrophic and heterotrophic foods, nutritional elements N, P to fish ponds. The physical structure of the model is simply consists of the epilimnion layer.

Table 1. *The matrix of mutual affecting factors.*

	PHP	ZOP	DON	MON	PPA	DOP	MOP	DOC	MOC
PHP	1	0	-	-	1	1	-	-	-
ZOP	1	1		1			1		1
DON	1	1	1	1					
MON	1	1		1					
PPA	1/0	1			1	1			
DOP	1	1				1	1		
MOP	1	1					1		
DOC	1	1						1	1
MOC	1	1							1

Note: 1 – Impact; 0 – No impact

PHP: Phytoplankton; ZOP: Zooplankton; DON: Dissolved Organic Nitrogen; MON: Molecular Organic Nitrogen; PPA: Phosphate; DOP: Dissolved Organic Phosphate; MOP: Molecular Organic Phosphate; DOC: Dissolved Organic Carbon; MOC: Molecular Organic Carbon.

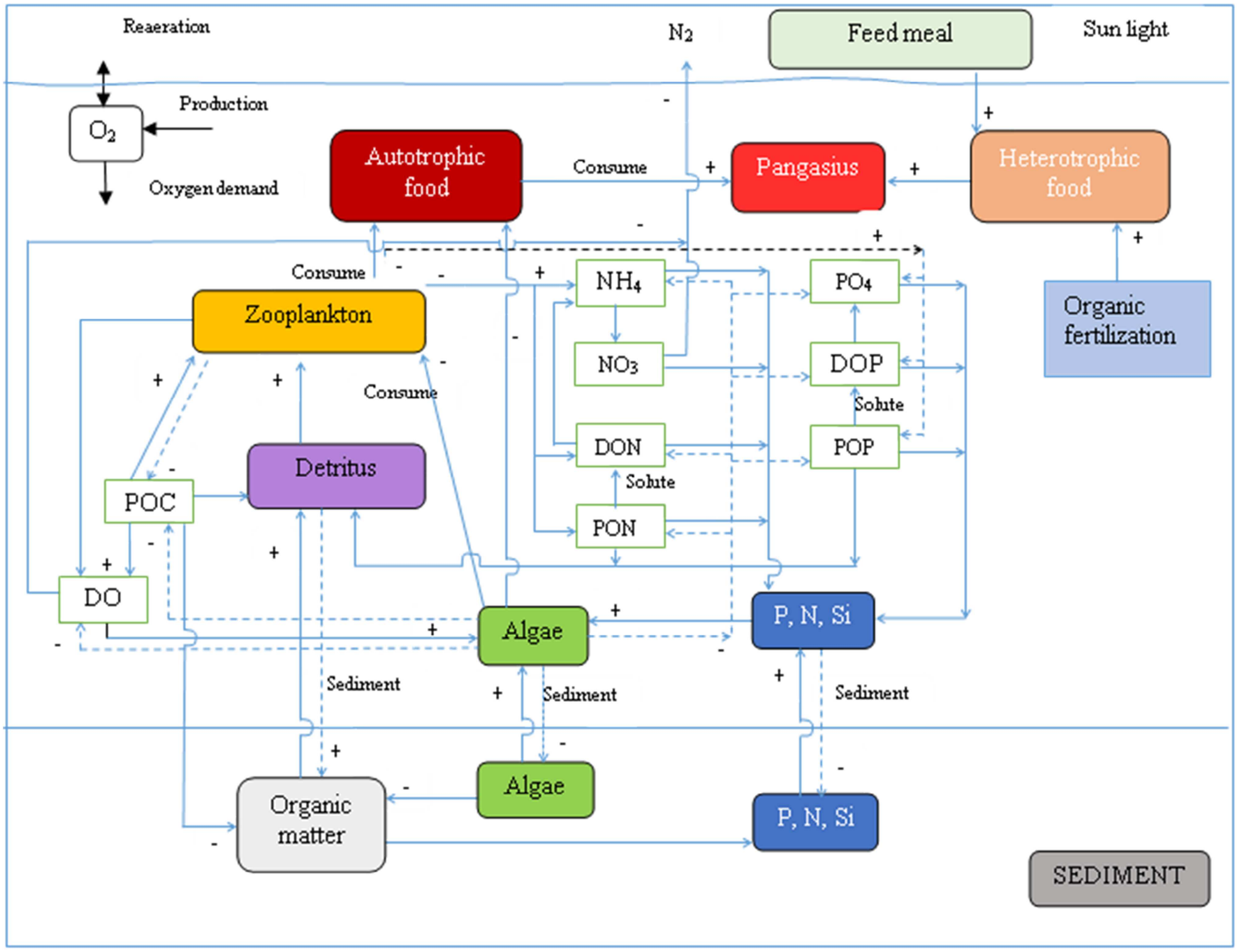

Figure 1. *Biological processes in pangasius ponds.*

2.5. Equation

Based on the correlation between the components in the pond, the equation describing biological processes in Pangasius pond is set as follows [12]:

2.5.1. Nitrogen

(i) Nitrate

$$\frac{\partial NO_{3(x)}}{\partial t} = -\sum_{i=diat,green,cyan}\left(1 - prefNH_{4(i,x)} \times N_{up(i,x)} \times N_{fb(i,x)} \times PHYT_{(i,x)} + nitrification_{(x)} - denitrification_{(x)}\right) - outflows \times NO_{3(EPI)} \quad (1)$$

$$prefNH_4 = 1 - exp(-\Psi_i * NH_4);$$

$$nitrification = nitrif_{max} * f_{lightnitr} * \frac{DO}{KH_{ONIT}+DO} * \frac{NH_4}{KH_{NH_4}NIT+NH_4} * f_{tempnitr} \quad (2)$$

$$f_{tempnitr} = \begin{cases} exp(-KT_{nitr1}(T - T_{optnitr})^2) \text{ khi } T \leq T_{optnitr} \\ exp(-KT_{nitr2}(T_{optnitr} - T)^2) \text{ khi } T > T_{optnitr} \end{cases} \quad (3)$$

$$f_{lightnitr} = \begin{cases} 1 \text{ khi } I \leq 0.1 * Id_t \\ 0 \text{ khi } I > 0.1 * Id_t \end{cases} \quad (4)$$

$$denitrification = R_{denitr/oxresp} * \frac{KH_{OOXRESP}}{KH_{OOXRESP}+DO} * \frac{NO_3}{KH_{NO_3DENIT}+NO_3} * K_{respdoc} * DENIT_{NO_3/DOC} * DOC \quad (5)$$

$$K_{respdoc} = K_{ref_{respdoc}} \times f_{temperature} \quad (6)$$

(ii) Ammonium

$$\frac{\partial NH_{4(x)}}{\partial t} = -\sum_{i=diat,green,cyan} prefNH_{4(i,x)} \times N_{up(i,x)} \times N_{fb(i,x)} \times PHYT_{(i,x)} - nitrification_{(x)} + \sum_{i=diat,green,cyan} FBM_{NH_4(i)} \times N_{(i,x)} \times bm_{ref(i)} e^{ktbm(i)(T(x)-Tref(i))} \times PHYT_{(i,x)} + \sum_{j=cop.clad} FBM_{NH_4(j)} \times \frac{N}{C_{(j)}} \times bm_{ref(j)} e^{ktbm(j)(T(x)-Tref(j))} \times ZOOP_{(j,x)} + KN_{mineral(x)} \times DON_{(x)} + \sum_{j=cop,clad} FE_{NH_4(j)} \times Negestion_{(j,x)} - outflows \times NH_{4(EPI)} \quad (7)$$

2.5.2. Phosphorous

(i) Dissolve organic Phosphorous

$$\frac{\partial DOP_{(x)}}{\partial t} = \sum_{i=diat,green,cyan} FBM_{DOP_{(i)}} \times P_{(i,x)} \times bm_{ref(i)} e^{ktbm(i)(T(x)-Tref(i))} \times PHYT_{(i,x)} + \sum_{j=cop,clad} FBM_{DOP(j)} \times \frac{P}{C_{(j)}} \times bm_{ref(j)} e^{ktbm(i)(T(x)-Tref(i)} \times ZOOP_{(j,x)} + KP_{dissolution(x)} \times DOP_{(x)} - KP_{mineral(x)} \times DOP_{(x)} + \sum_{j=cop,clad} EF_{DOP(j)} \times Pegestion_{(j,x)} - outflows \times DOP_{(EPI)} \quad (8)$$

$$Pegestion_{(j,x)} = \left(\sum_{i=diat,green,cyan} Grazing_{(i,j)} * P_{(i)} + Grazing_{detritus(j)} \times POP / POC^{(*)}\right) * \left(1 - gref_{(j)}\right) * f_{temperature(j)} * ZOOP_{(j)} \quad (9)$$

(ii) Particulate organic Phosphorus

$$\frac{\partial POP_{(x)}}{\partial t} = -\sum_{i=diat,green,cyan} FBM_{POP(i)} \times P_{(i,x)} \times bm_{ref(i)} e^{ktbm(i)(T(x)-Tref(i))} \times PHYT_{(i,x)} + \sum_{j=cop,clad} FBM_{POP_{(j)}} \times \frac{P}{C_{(j)}} \times bm_{ref(j)} e^{ktbm(j)(T(x)-Tref(j))} \times ZOOP_{(j,x)} - KP_{dissolution(x)} \times POP_{(x)} - \frac{\sum_{j=cop,clad} Grazing_{detritus(j,x)} \times POP_{(x)}}{POC_{(x)}} * \times f_{temperature(j,x)} \times ZOOP_{(j,x)} - VP_{seltling} \times f_{temperature(x)} \times POP_{(x)} \times f_{depth(x)} + \sum_{j=cop,clad} FE_{POP(j)} \times Pegestion_{(j,x)} - outflows \times POP_{(EPI)} \quad (10)$$

2.6. Model Solving Method

The differential equations cannot be solved by conventional analytical methods but must be approximated by numerical as Picard approximation, Taylor series, power series, Euler, Runge - Kutta method. Among these methods, the Runge - Kutta is the most effective: it is both highly accurate, the algorithm is not too complicated, is applied extensively to solve differential equations.

The equations after solving will be coded and simulated by Matlab software version 2019.

3. Results

3.1. Model Calibration

The model need to calibrated by identifying the main dynamic factors as well as the effect values to the model.

Table 2. *Range values of dynamic factors.*

Factor	growthmax(i) (day^{-1})	bmref(i) (day^{-1})	grazingmax(j) (day^{-1})	KZ(j) (mg C m^{-3})
Value	1.2 – 2.5	0.06 – 0.12	0.3 – 1.0	60 - 150
Factor	KEXTback(m^{-1})	Vsettling(i) ($mday^{-1}$)	Pupmax(i) (mg P mgC^{-1} day^{-1})	Pmax(i) (mg P mgC^{-1})
Value	0.17 - 0.4	0.1 – 0.5	0.006 – 0.7	0.001 – 0.01
Factor	Pmin(i) (mg P mgC^{-1})	C:P(j)	T(°C)	Depth(x)(m)
Value	0.004 – 0.01	20 - 80	27 - 36	3 - 7
Factor	Pred1 (day^{-1})			
Value	0.6			

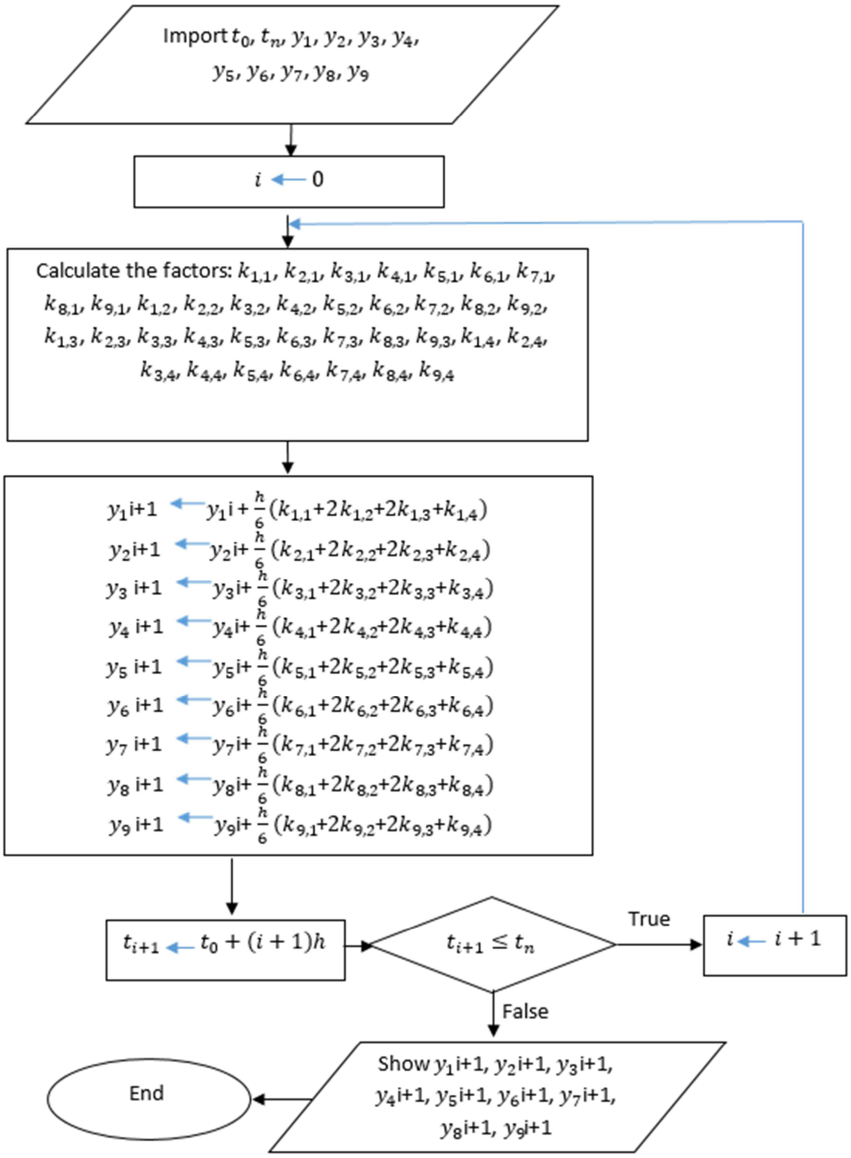

Figure 2. *Algorithm diagram of Runge – Kutta.*

The calibration of the model by using the data which was measured in Washington lake [12] and adjusted by data measured in the pond in Vietnam. This will help to adjust the parameters suit to the Vietnam weather condition.

3.2. Phosphorous

Inorganic nitrogen and inorganic phosphorus are considered essential components in fish nutrition. Total dissolved inorganic nitrogen and dissolved inorganic phosphorus in water and total nitrogen and phosphorus sediment are considered as four important state variables.

a) The concentrations of Phytoplankton were adjusted by total dissolved inorganic nitrogen and dissolved inorganic phosphorus.
b) Total loss of nitrogen (ammonium diffused in the air and denitrification of nitrite, nitrate) was considered a small fraction of the total dissolved inorganic nitrogen.

Because there is no actual data then organic phosphorus is indirectly adjusted via TP. Thus, the calibration of phosphorus between the actual value and the model is expressed through PO_4^{3-} and TP.

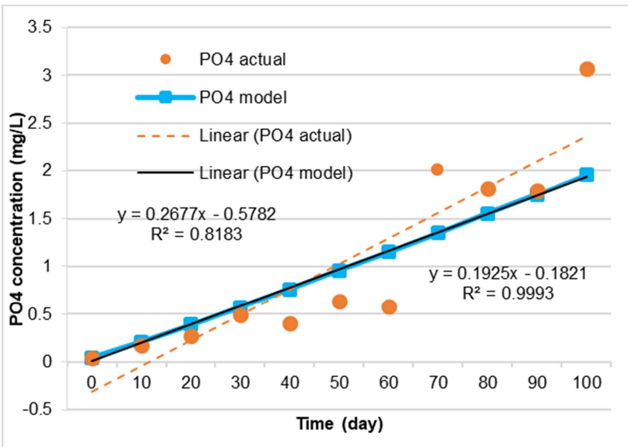

Figure 3. *Modeling result of PO_4^{3-}.*

Table 3. Result of modeling PO_4^{3-} and TP (mg/l).

Date	0	10	20	30	40	50	60	70	80	90	100	MSE	RMSE
PO_4 actual	0.043	0.174	0.273	0.498	0.404	0.641	0.582	2.01	1.82	1.79	3.07	0.159	0.399
PO_4 model	0.043	0.209	0.391	0.574	0.761	0.957	1.153	1.350	1.552	1.754	1.956	0.000	0.016
Error (%)	0	20.11	43.08	15.20	88.47	49.25	98.08	32.82	14.73	2.03	36.29		
TP actual	0.098	0.272	0.521	1.06	0.544	0.853	1.80	2.135	2.377	2.764	3.924	0.138	0.371
TP model	0.098	0.350	0.614	0.86	1.120	1.380	1.63	1.889	2.148	2.403	2.658	0.000	0.003
Error (%)	0	28.72	17.89	18.3	105.8	61.76	9.32	11.53	9.66	13.06	32.26		

Note: MSE - Mean Square Error; RMSE: Root Mean Square Error.

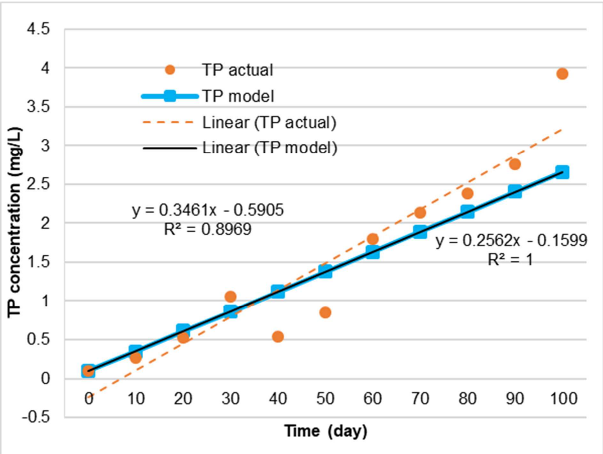

***Figure 4.** Modeling result of TP.*

The average error of correction graph PO_4^{3-} and TP are 40% and 30.83% (≤40%, respectively). The MSE and RMSE of PO_4^{3-} in actual are 0.159 and 0.399 and in model are 0.000 and 0.016 meanwhile MSE and RMSE of TP in actual are 0.138 and 0.371 and in model are 0.000 and 0.003. The difference that the model cannot simulate is due to objective factors such as changes in weather conditions, temperatures that are no longer ideal, or because of the small number of dead fish (0-6%) during the growth and development of Pangasius, change in human management: addition and exchange of water.

Both the PO_4^{3-} and TP in the correction graphs reflect the increasing trend over time of the phosphorus. The amount of phosphorus increases gradually over time was correlated with the increase of fish biomass, this is due to the percentage of TN, TP contributed from the input and output components, the initial water supply of% P is only 0.05% while 97.5% is from food added to the pond. This food intake increases with the growth of the fish. In addition to the increase in phosphorus due to the contribution to the pond by the amount of excess feed. The amount of phosphorus is also contributed by the metabolism and excretion of the fish because according to the data table also shows, initially in the fingerlings there is only 1.8% P, harvest is 22.17% P and dead fish account for 8.70% P.

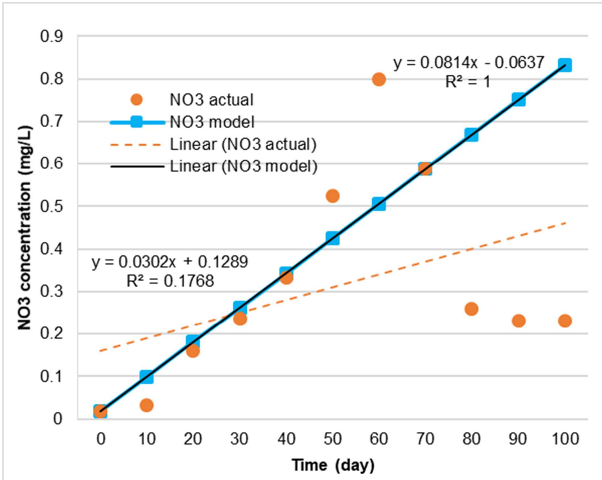

***Figure 5.** Modeling result of NO_3^-.*

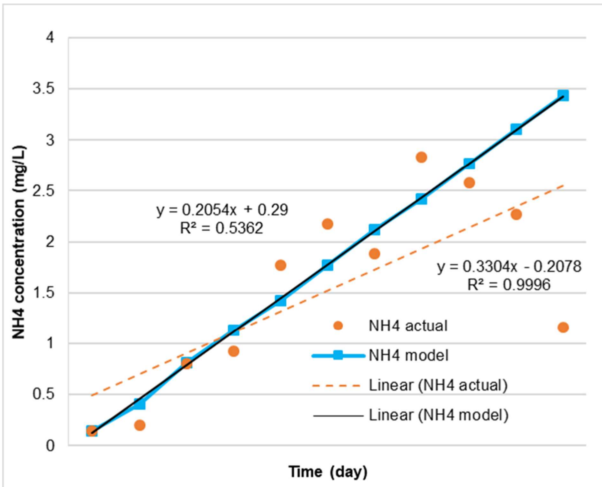

***Figure 6.** Modeling result of NH_4^+.*

Table 4. Result of modeling NO_3^- NH_4^+ (mg/l).

Day	1	10	20	30	40	50	60	70	80	90	100	MSE	RMSE
NO_3 actual	0.018	0.033	0.160	0.236	0.333	0.524	0.80	0.588	0.259	0.230	0.232	0.043	0.206
NO_3 model	0.018	0.099	0.181	0.262	0.343	0.425	0.506	0.588	0.669	0.751	0.832	0.000	0.000
Error (%)	0	200	12.78	10.97	3.09	18.95	36.33	0.071	158.3	226.2	258.5		
NH_4 actual	0.146	0.2	0.806	0.924	1.77	2.18	1.88	2.83	2.58	2.27	1.16	1.343	1.159
NH_4 model	0.146	0.406	0.814	1.131	1.419	1.771	2.115	2.416	2.764	3.105	3.432	0.005	0.072
Error (%)	0	103	1.02	22.45	19.85	18.77	12.49	14.64	7.12	36.78	195.8		

3.3. Nitrogen

Because there is no actual data, the organic nitrogen is indirectly adjusted through total nitrogen. Thus, the calibration results of nitrogen between the actual value and the model are expressed through NO_3^-, NH_4^+, and TN.

The average error of NO_3^- and NH_4^+ in the correction graphs was 40.31% and 27.47%, respectively, during the first 70 days of the survey. In the 30 days later, the value found in the model continued to increase while the actual measured value dropped rapidly. Errors in the last 30 days when adjusting NO_3^- showed huge differences (>100%). Part of the difference is that the model cannot simulate the objective factors acting in real conditions. While the average error of experiments is 17.74%, the trend of change is relatively similar between actual data and simulation from the model. The MSE and RMSE of NO_3^- in actual are 0.043 and 0.206 and in model are 0.000 and 0.000 meanwhile MSE and RMSE of NH_4^+ in actual are 1.343 and 1.159 and in model are 0.005 and 0.072; MSE and RMSE of TN in actual are 0.195 and 0.441, in model are 0.001 and 0.031 respectively.

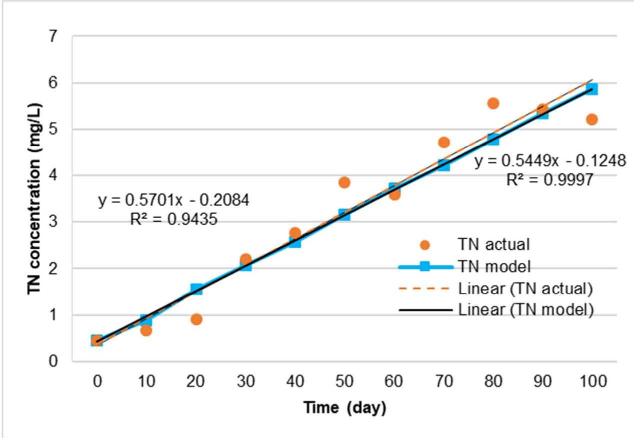

Figure 7. *Modeling result of TN.*

Table 5. *Result of modeling TN (mg/l).*

Day	1	10	20	30	40	50	60	70	80	90	100	MSE	RMSE
TN actual	0.442	0.664	0.91	2.2	2.77	3.85	3.59	4.71	5.55	5.43	5.22	0.195	0.441
TN model	0.442	0.891	1.556	2.070	2.573	3.161	3.708	4.219	4.788	5.331	5.852	0.001	0.031
Error (%)	0	34.13	70.93	5.93	7.13	17.89	3.30	10.43	13.73	1.82	12.11		

From model data and reality shows that concentrations of NO_3^- and NH_4^+, TN in ponds increased rapidly during the development of Pangasius, correlated with an increase in fish biomass, fish size. This is explained by the fact that fingerlings account for only 1.17% N while harvested fish account for 33.1% N. This growth due to 95.28% N in the supplementary feed added to the initial pond helps to create the small amount of leftovers feed dissolves in water along with the metabolism of fish (excreted), which increases nitrogen concentration over time.

Total organic nitrogen after adjustment through TN gave a slight increase in value in 100 days (~ 1 mg/L) compared to NO_3^- and NH_4^+.

The results indicated that simulated inorganic nitrogen and phosphorus were strongly influenced by nutritional and feed supplementation. That is, the concentration of inorganic nitrogen and phosphorus increases with the addition of inorganic fertilizer and decreases due to both assimilations of phytoplankton and environmental losses. As the addition of inorganic nitrogen and inorganic phosphorus is applied weekly, the depletion of inorganic nitrogen and phosphorus can be compensated by the nutritional supplementation and feed supplement processes.

4. Discussion

The data result of modeling for PO_4^{3-} and TP were same as other research. According to Truong Quoc Phu (2007) [6], concentration P-PO_4^{3-} recommended for aquaculture was 0.005-2 mg/L. Concentration P-PO_4^{3-} investigated at these ponds were higher than recommendation but in the striped catfish (pangasius) production the feed consumed was very high, which caused a high accumulation wastes. Chau Minh Khoi (2012) [15] also given that in An Giang province (Vietnam), P-PO_4^{3-}in the pond had value at 8 mg/L, higher than these research values but the fish was still alive. The content of dissolved phosphorus (PO_4^{3-}) in the water of catfish ponds is also relatively high. The concentration of PO_4^{3-} fluctuated 0.003-2.28 mg/L [16] or 0.021-1,636 mg/L [17]. According to Boyd [7], the PO_4^{3-} concentration suitable for aquaculture ponds is in the range of 0.005-0.2 mg/L, when the PO_4^{3-} concentration is lower than 0.005 mg/L the algae stops growing and when the PO_4^{3-} concentration reaches 0.2 mg/L algae will bloom. However, if the continued supply of PO_4^{3-} exceeds the needs of the algae, it will be toxic to the algae, leading to the perish of algae. In pangasius ponds, the PO_4^{3-} concentration is too high at the end of the growing season, which is why the algae are easily destroyed during this period.

The data results of modeling for NO_3^-, NH_4^+ and TN were also same as other research [6], [15] in the field and still safe for pangasius. Nitrate (NO_3^-) content in catfish ponds is usually low at the beginning of the season but increases very high at the end of the growing season. The concentration of NO_3^- in catfish pond water fluctuates in the range of 0.034-19.5 mg/L [9] or 0.12-18.0 mg/L [16]. The total nitrogen (TN) content of catfish ponds is very high compared to the most intensive culture ponds of other aquaculture species. According to Cao Van Thich [5], the concentration of TN at the beginning of the season was about

4-5 mg/L and increased at the end of the growing season, reaching the highest level of approximately 60 mg/L when extending the period to 8 months. However, Le Bao Ngoc [9] recorded the highest concentration of TN at only 21 mg/L during the culture period of about 7 months. At the end of the farming season, the biomass of fish in the pond is high, the amount of food provided to fish daily is very large, so the amount of leftover food, as well as fish waste, increases rapidly the TN content in the water; The longer the culture period, the higher the TN content in the water.

5. Conclusions

The modeled PO_4^{3-} concentration is in the range of 0.043 - 1.956 mg/L while in actual it was 0.043 - 3.07 mg/L with an average error of 40%; The simulated TP concentration ranges from 0.098 to 2.658 mg/l and actual was 0.098 - 3,924 mg/l with an average error of 30.83%. For nitrogen, the study showed results of three components including modeled NO_3^- concentration in the range of 0.018 - 0.832 mg/L and actual was in the range of 0.018 - 0.8 mg/L with an average error of 40.31%; NH_4^+ model concentration in the range of 0.146 – 3.432 mg/l and actual was in the range of 0.146 - 2.83 mg/L with an average error of 27.47%; Concentration of TN model was in the range of 0.442 - 5.852 mg/L and actual was 0.442 - 5.55 mg/L with an average error of 17.71%.

The study has established a mathematical model used to simulate and calculate the transformation process of major nutrients in catfish ponds including DO, TN, TP at different times. Adjusted results of the model with real data give quite similar results showing that the model created reflects some biological processes in Pangasius ponds. Initially, the model helped to support the management, simulating several scenarios to change the objective and subjective factors to identify influencing factors, and provide the best management solutions.

The model supports in calculating the concentration of nutrient as well as environmental indicators as PO_4^{3-}, TP, NO_3^-, NH_4^+, TN in pangasius pond which helps to optimize the fish production and reduce the environment impact. The model needs to research more in modeling to find the suitable dynamic factors for the best model of pangasius pond in Vietnam.

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