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Water Quality in Intensive Climbing Perch Ponds (*Anabas testudineus*) and Suggestion for Better Management of Wastewater Discharge

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***Abstract**: Climbing perch (Anabas testudineus) is widely distributed in the Mekong Delta and is a favorite dish of several families. Due to the severe decline of wild climbing perch polulation, semi-intensive cultivation using natural foods does not meet demand and economic efficiency is not high. Therefore, intensive climbing perch cultivation has been strongly developed in Can Tho city, Viet Nam in order to diversify food sources fulfilling consumer demand. Intensive farming model takes advantage of small area of water surface, high density of fingerlings, and high rate of feeding thus speeding fish growth and harvesting period. However, intensive farming can lead to environmental problems due to leftover feeds. This study aimed to assess the water quality in 6 intensive climbing perch culturing ponds in which 3 ponds using home-made feed and 3 ponds using industrial feed. River water samples were collected at the same time as control to compare quality of water with the intensive climbing perch cultivating ponds. The results show that water quality in the intensive climbing perch culturing ponds were heavily organically polluted (DO was low while BOD and COD were very high) in which the use of home-made feeds for intensive aquaculture resulting in more environmental problems. Wastewater from intensive culturing ponds if directly discharged to the river would cause eutrophication and seriously pollute river water due to high concentrations of* NH_4^+*-N, TKN and TP. Replacement of home-made feed by other suitable feed and treatment of wastewater from the ponds before discharging into receiving source were recommended to prevent environmental problems. Master planning and raising awareness of law enforcement and policies on environmental protection are urgently needed to reduce environmental pollution in aquaculture.*

***Key words**: Home-made feed, industrial feed, Anabas testudineus, intensive climbing perch cultivation, organic pollution*

1. Introduction

The Mekong Delta is downstream of the Mekong River, which is considered to be the most prosperous region, not only in Vietnam but also in Southeast Asia, and is also considered a key region for export of aquacultural products. Climbing perch is a freshwater fish that is well adapted to different terrains such as ponds, lakes, swamps, rivers, and rice fields. It is a preferred source of food for human consumption so it has high economic value. Recently, production of climbing perch fingerling has been successful (Tuan et al., 2002) making it becomes a commercial species with strong prospects for development in the Mekong Delta (Phú et al., 2006). Semi-intensive farming of climbing perch is not sufficient to meet demand for consumption since it takes long time, requires large area of surface water, and high capital investment and low profit. To be more economic efficiency, the intensive farming, which cultivates climbing perch in high density, uses smaller area of surface water and provides higher amounts of artificial feeds, is a solution to sufficiently supply climbing perch for increasing demand. However, the intensive farming shows its disadvantage because significant higher amounts of feeds including industrial feed and home-made feeds are required and costly. In fact, only about 17% of fish feed is absorbed and the rest is dissolved in water environment in cultivating ponds (Phú, 2003). The amount of leftovers consequently contributes to environmental pollution in the Mekong Delta.

The variation of water quality in intensive cultivating ponds of *Clarias macrocephalus* (Nga and Nghiệp, 2009), and *Pangasianodon hypophthalmus* (Nguyên et al., 2014) have been investigated. However, there have been no reports for water quality from intensive cultivation of *Anabas testudineus*. This study was conducted to assess water quality in intensive farming of climbing perch using home-made feed and industrial feed and to propose solutions to minimize water-related problems for receiving water.

2. Methodology

2.1 Composition of industrial and home-made feeds

The industrial feed with commercial name Viet Long VL32 was used to feed climbing perch. The main ingredients of the industrial feed were protein (30%), total minerals (12%), fat (5%), fiber (6%), calcium (2%), and phosphorus (1%) and other additives. Unlike industrial feed, home-made feed was made from bone powder (57-62%), discarded fish (20-25%), bran (10%), binding powder (3%) and digestive additives (0.2%).

2.2 Sampling sites

Table 1. Characteristics of sampling ponds.

Characteristics	HMF 1	HMF 2	HMF 3	IF 1	IF 2	IF 3
Area of ponds (m^2)	400	600	1000	312	120	200
Age of fish (month)	4	4	4	4	4	4
Density of fish (fish/m^3)	63	63	80	39	67	60
Weight of fish (g/fish)	4	4	4	4	4	4
Depth (m)	1,2	0,8	1	1	1,2	1,2

Water samples were collected in six intensive farming ponds of climbing perch, three of which used home-made feed (namely HMF1, HMF2, and HMF3) and three ponds using industrial feed (namely IF1, IF2, and IF3). River water sample (denoted R) was also collected to compare with the water quality in the fish ponds. Characteristics of climbing perch and the ponds were described in Table 1.

2.3 Sampling and analysis of water samples

Collection of water samples was performed four times for every even days. Samples were collected at three different points in each pond, analyzed water quality parameters independently, and the mean values of each parameter were reported.

Temperature, pH, dissolved oxygen (DO), and turbidity were measured directly at the field by the handheld meters. Water samples for analysis of biological oxygen demand (BOD), chemical oxygen demand (COD), ammonium nitrogen (NH_4^+-N), total kjeldahl nitrogen (TKN), and total phosphorus (TP) were collected, preserved properly and transported to the Environmental Quality laboratory, Department of Environmental Science, College of Environment and Natural Resources, Can Tho University for analysis using the standard methods (APHA, 1998).

2.4 Statistical analysis

The significant difference in mean values of the environmental quality parameters was tested using IBM SPSS statistics for Windows Version 19.0 software (IBM Corp., Armonk, NY, USA). The significant difference (P <0.05) was determined by analysis of variance (ANOVA) and then Duncan test (Ahrari et al., 2015).

3. Results and Discussion

3.1 Variation of water quality parameters

The temperatures in water from the ponds using home-made feed, industrial feed and river were 29.2 ± 0.22 ^{o}C, 29.6 ± 0.10 ^{o}C, and 29.1 ± 0.9 ^{o}C, respectively (Figure 1). There was no significantly different (p> 0.05) in temperature in these sampling sites. The temperature of water mainly depends on the temperature of the surrounding environments and the energy of the decomposition of organic compounds in the pond. The results indicated that temperatures in the ponds were in the suitable range for fish cultivation (Phú, 2003).

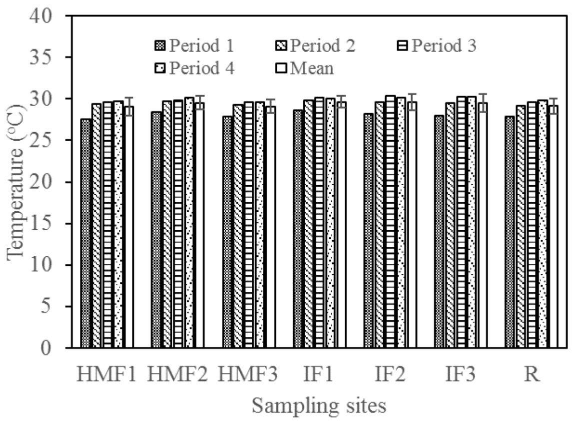

Figure 1. Temperature in ponds and river over the study period. Mean is the average of temperature of the four sampling periods. Error bar indicates standand error.

Turbidity variation in each pond and river water over 4 sampling times was shown in Figure 2. The mean turbidity in ponds using home-made feed was 175.9 ± 14.8 NTU, industrial feed was 89.5 ± 11.1 NTU and in the river water was 73.4 ± 27.2 NTU. Results of statistical analysis showed that turbidity in the ponds using industrial feed and in river water did not differ significantly (p> 0.05) while turbidity in ponds using home-made feed was significantly different from those in ponds using industrial feed and river water (Figure 2). This could be because home-made feed exhibited higher disintegration level resulting in more difficulty in controlling the unused amount of feed than that from industrial feed. In aquacultural ponds, turbidity usually ranges from 10 to 50 NTU (Boyd, 1998). As can be seen that the turbidity in the ponds found in this study was very high, but climbing perch is highly tolerant to polluted water environment (low dissolved oxygen or high organic matters).

The pH values in the four surveys were less fluctuating and in the lower range of neutrality (Figure 3). The mean pH values in ponds using home-made feed, industrial feed and river water were not significantly different (p = 0.089). These pH values do not affect on the survival and growth of freshwater aquatic species (Boyd, 1998) especially the climbing perch.

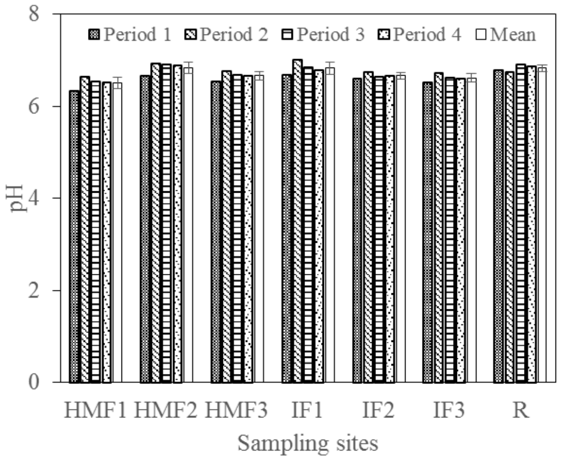

Figure 3. pH in the ponds and river over the study period. Mean is the average of pH of the four sampling periods. Error bar indicates standand error.

Dissolved oxygen (DO) concentrations throughout the sampling periods were shown in Figure 4. The results showed that DO in ponds using home-made feed and industrial feed were were 1.6 ± 0.10 mg/L and 2.1 ± 0.10 mg/L, respectively which were very low. It was previously reported that minimial DO of 2 mg/L is required for climbing perch ponds (Trình, 1997). DO of 6-8 mg/L is suitable for fish living in freshwater environments (Xuân, 1994). DO value in the river (3.5 ± 0.48 mg/L) was significantly higher and was statistically different from DO measured in the ponds, however this value was very low compared to national technical standards on surface water quality for domestic use (QCVN 08-MT:2005/BTNMT) which requires DO ≥ 6 mg/L. River water quality at the study site was only suitable for agricultural irrigation and transportation and it was not safe for domestic use.

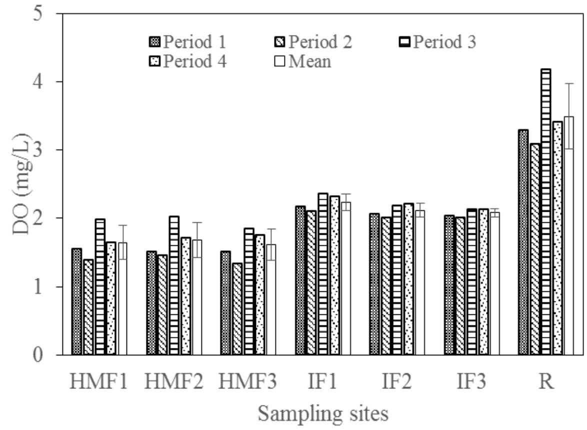

Figure 4. **DO in the ponds and river over the study period. Mean is the average of DO of the four sampling periods. Error bar indicates standand error.**

The COD concentrations in the ponds and in river water were presented in **Figure 5**. The results showed that concentrations of COD in water from ponds using home-made feed (87.0 ± 18.3 mg/L) and industrial feed (54.5 ± 0.9 mg/L) were very high and significantly different with that from river water (12.87 ± 4.42 mg/L). This indicated that the feeds for cultivation of climbing perch seriously affect on water quality in the ponds. The COD results were consistent with the measurements of DO in the same ponds that high COD concentrations lead to significantly reduced DO in water.

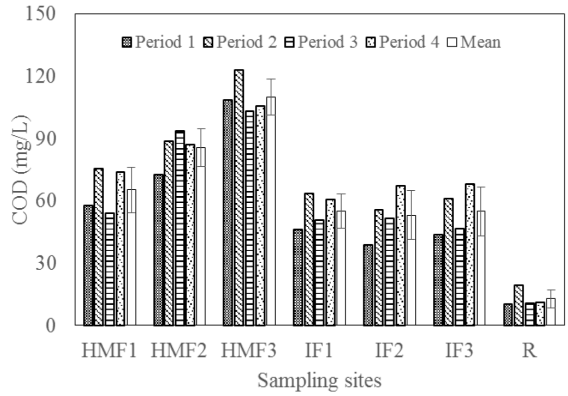

Figure 5. COD in the ponds and river over the study period. Mean is the average of COD of the four sampling periods. Error bar indicates standand error.

Clean water has COD value in the range of 6-20 mg/L (Uyển and Nga, 2000). This study clearly showed that river water, in terms of COD was classified as clean, water in ponds using industrial feed was polluted while water in ponds using home-made feed was heavily polluted.

The concentrations of BOD were shown in **Figure 6**. The average BOD_5 concentrations in ponds using home-made feed, industrial feed and river water were 38.3 ± 7.17 mg/L, 24.2 ± 1.26 mg/L, and 4 ± 1 mg/L, respectively. These values were statistically significant indicating cultivation of climbing perch and selection of feed types importantly influence on water quality in the ponds. The poor quality of water in the ponds posed a significant risk on surface water quality in the surrounding area. The BOD_5 value which is suitable for aquaculture ponds is less than 10 mg/L (Phú, 2003). BOD_5 of river water was low which was appropriate for fish. However, BOD_5 in the ponds using industrial and home-made feeds were 2.4 and 3.8 times higher than permissible level for aquacultural ponds. BOD_5 in the river was not exceeded the limit of QCVN 08-MT: 2015/BTNMT.

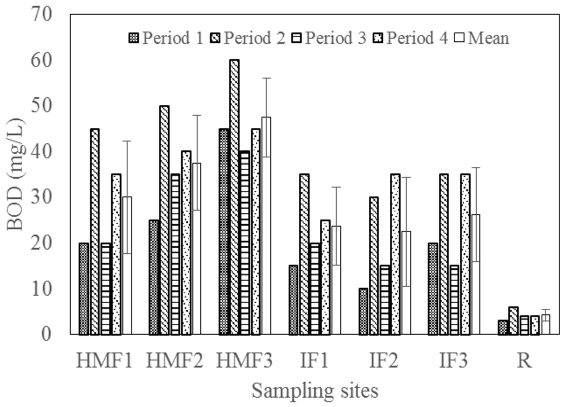

Figure 6. BOD_5 in the ponds and river over the study period. Mean is the average of BOB_5 of the four sampling periods. Error bar indicates standand error.

Figure 7 showed the NH_4^+-N concentrations in the ponds and the river. The averaged values of NH_4^+-N in the climbing perch ponds using farm-made feed, industrial feed and river water were 9.2 ± 1.0 mg/L, 5.8 ± 1.03 mg/L, and 1.00 ± 0.30 mg/L, respectively. The difference between these values was statistically significant indicating that the cultivation of fish and choice of feed types exhibited significant influence on the NH_4^+-N amounts released into the water environment. Concentration of suitable NH_4^+-N for intensive culture ponds is less than 4 mg/L (Long, 2002) while for aquacultural ponds is in the range of 0.2-2 mg/L (Boyd, 1998). The results clearly showed that the fish ponds using industrial and home-made feed produced high levels of NH_4^+-N which could be converted to ammonia resulting in toxicity impact on fish and other aquatic species (Boyd, 1998; Phú, 2003). Concentration of NH_4^+-N in river water (1.00 ± 0.30 mg/L) was higher than the level (0.30 mg/L) regulated by QCVN 08-MT: 2015/BTNMT for domestic use.

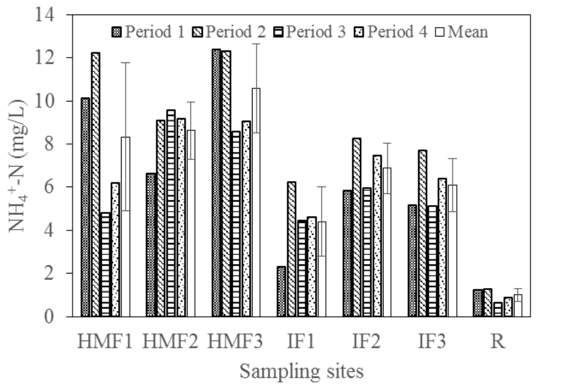

Figure 7. NH_4^+-N in the ponds and river over the study period. Mean is the average of NH_4^+-N of the four sampling periods. Error bar indicates standand error.

The results of total kjeldahl nitrogen (TKN) analysis were presented in **Figure 8**. TKN in the climbing perch ponds fed with home-made feed ranged from 13.6 ± 2.69 to 17.25 ± 0.36 mg/L, while in the ponds using industrial feed were from 9.44 ± 0.59 to 11.13 ± 0.41 mg/L. Mean values of TKN in the ponds using home-made, industrial feed and river water were significantly different and the values were 14.9 ± 1.7 mg/L, 10.4 ± 0.70 mg/L, and 3.51 ± 0.46 mg/L, respectively. It clearly indicated that a large amount of nitrogen exists in organic form derived from leftovers, fish excreta and some other sources. However, the contribution of cultivating climbing perch intensively to nitrogen source in water was very significant, and if this is not treated well before being discharged into receiving river, it would cause severe degradation of surface water quality.

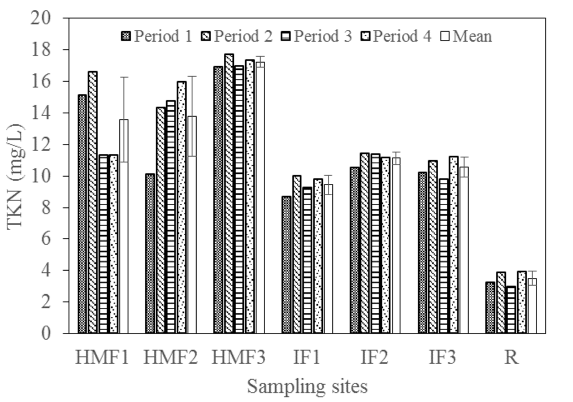

Figure 8. TKN in the ponds and river over the study period. Mean is the average of TKN of the four sampling periods. Error bar indicates standand error.

Phosphorus is one of the essential nutrients for living organisms. Phosphorus in water also reflects possibility of causing entrophication for water body. Therefore, the determination of phosphorus concentration in water is significant in the management of water quality in intensive cultivating ponds.

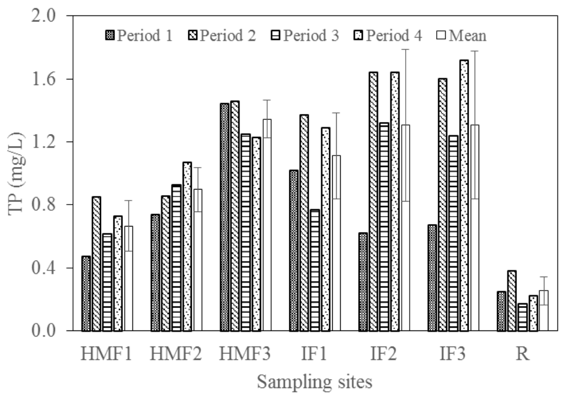

Figure 9. TP in the ponds and river over the study period. Mean is the average of TP of the four sampling periods. Error bar indicates standand error.

The present study showed that total phosphorus did not fluctuate between ponds using industrial feed (1.24 ± 0.10 mg/L) and home-made feed (0.97 ± 0.28 mg/L) but there was significantly different between the intensive climbing perch cultivating ponds and river water (0.26 ± 0.09 mg/L) (**Figure 9**). The results indicated that the intensive cultivation ponds would significantly release phosphorus into water via unused feed and metabolite products. It was previously reported the intensive cultivation ponds of *Clarias microcephalus* and *Pangasianodon hypophthalmus*, TP concentrations ranged from 0.04 to 1.68 mg/L (Lam Mỹ Lan and Kwei, 2004) and 1.57 and 2.20 mg/L (Ngọc, 2004), respectively. The results of phosphorus obtained in this study were in line with those in *Clarias microcephalus* culturing ponds but it were lower than those of intensive *Pangasianodon hypophthalmus* ponds.

3.2 Water quality assessment for intensive climbing perch culturing ponds

The results showed that the physical and chemical parameters of river water were suitable for aquaculture. However, in comparison with the surface water quality standard (QCVN 08-MT: 2005/BTNMT), the DO, NH_4^+-N were not met the requirement and showed signs of organic pollution. In addition, turbidity of river water was relatively high due to the presence of suspended matter making river water no longer suitable for domestic use.

In the intensive ponds of climbing perch, the temperature and pH of the ponds using industrial and home-made feeds were in the acceptable range for growing fish. However, turbidity in the ponds using home-made feed was higher than those of the ponds using industrial feed and river water. Similarly, the paramenters indicating organic pollution such as DO, BOD, and COD in the ponds using home-made feed were significantly higher than those in the ponds using industrial feed. These ponds were heavily polluted by organic matters and this is in accordance with the former report that heavily organic pollution is often found in intensive aquaculture systems (Nga and Nghiệp, 2009; Nguyên et al., 2014)

The nitrogen containing parameters (NH_4^+-N and TKN) in the intensive ponds were higher than those of the river water. The concentrations of NH_4^+-N and TKN in the ponds using home-made feed were significantly higher than those in the ponds using industrial feed. Higher TKN concentration than NH_4^+-N indicated that large amounts of nitrogen exist in the form of nitrite, nitrate or organic nitrogen. In addition, the results showed that there was no significant difference in total phosphorus concentrations in the intensive ponds, but TP in ponds were much higher (3.8 – 4.8 times) than those found in river water. The richness of nitrogen and phosphorus in water received from the intensive ponds could lead to eutrophication resulting in more serious environmental problems.

3.3 Estimation of COD and NH_4^+-N amounts from the intensive climbing perch ponds

This study estimated the amounts of COD and NH_4^+-N discharged into the receiving water. The estimated results were based on mean values of COD and NH_4^+-N in each pond over 4 sampling periods with time interval of seven days. The volumes of water column were calculated based on areas and and depths of the ponds which were obtained from interviewing farmers of climbing perch. According to the interview with pond owners, the ponds' water were changed four times a month and each time about 20% of pond water was replaced. Results of estimation were presented in Table 2.

As can be seen that the amounts of COD and NH_4^+-N were proportional to the volume of water in the ponds meaning that the larger the pond's water volume, the greater the amounts of COD and NH_4^+-N released into the environment. Total amounts of COD and NH_4^+-N estimated to be discharged into the environment were 176.38 kg/month and 18.03kg/month, respectively. In the previous section, it was demonstrated that the concentrations of COD and NH_4^+-N in river water were 12.87 ± 4.42 mg/L and 1.00 ± 0.30 mg/L, respectively which exceeded the national standard for surface water (QCVN 08-MT: 2005/BTNMT) (for COD and NH_4^+-N are 10 mg/L and 0.30 mg/L respectively). The river water could not receive wastewater from the intensive climbing perch ponds. Wastewater from the intensive ponds should be treated thoroughly to meet the surface water quality standard before discharging to the river. Currently, there was no treatment facility for the treatment of wastewater from the intensive ponds. The release of wastewater from the ponds into the river will seriously destroy water quality and result in other related-water pollution problems.

Table 2. Estimation of COD and NH_4^+-N amounts from the intensive climbing perch ponds

Site	Area (m^2)	Depth (m)	Volume of pond (m^3)	COD (mg/L))	NH_4^+-N (mg/L)	COD (kg/month)	NH_4^+-N (kg/month)
HMF1	400	1.2	480	65	8.3	24.96	3.19
HMF2	600	0.8	480	86	8.6	33.02	3.30
HMF3	1000	1	1000	110	10.6	88.00	8.48
IF1	312	1	312	55	4.4	13.73	1.10
IF2	120	1.2	144	53	6.9	6.11	0.79
IF3	200	1.2	240	55	6.1	10.56	1.17
Total	**2632**	**6.4**	**2656**	**424**	**44.9**	**176.38**	**18.03**

3.4 Suggestion for better management of wastewater discharges from intensive climbing perch ponds

The pollution of water caused by intensive farming of climbing perch need to be carefully addressed to prevent unexpected consequences resulting from heavy water pollution. Solutions to this problem could be recommened as the following.

Firstly, planning is perhaps the best preventive solution. By planning, environmental manager can set a more suitable location to allow aquaculture operations to take place with minimally damaging the environment. Along with the planning solution, it is mandatory for aquaculturists to make environmental protection plans, perform environmental impact assessment according to their scales of farming activities. The commitment to implement strictly and voluntarily what have been stated in the approved environmental protection plans and environmental impact assessment reports is the best solution to prevent environmental problems from aquaculture.

Secondly, to manage the water source efficiently, environmental manager needs to calculate the assimilation capacity of receiving streams. Once the assimilation capacity of a river is fully understood, operation of aquacultural activity can be liciensed and discharge permit can be issued. No license is offered when a stream reached the assimilation limit. This is a common approach that has been successfully applied in the world to control water pollution which take into account for both point sources and scattering sources. Through this approach, the discharge permits could be traded among wastewater dischargers. Wastewater dischargers who treat their wastewater thoroughly may negotiate with unsatisfactory wastewater processors to pay for the parts that their treatment could not meet the discharge permit. However, in order to arrive at this approach, more in-depth and complete studies on assessment of assimilation capacity of wastewater receiving streams should be conducted.

Thirdly, setting priority for economic development and environmental law enforcement should be harmonized. It is likely that environmental issues have not been properly considered. High priority is given to economic development, while the ability to solve environmental problems resulted from econmic activites is limited due to lack of high quality human resources and treatment technology. The law enforcement in the field of environment is not strictly implemented because there is conflict in environment and social-economic policies which call for investment in industries and creation of jobs for society. Fees for environmental protection are collected but they are not re-invested for environmental issues, for example capacity building and technology. The fine in violation in the field of environmental protection is not sufficiently high to reduce and prevent causing environmental damage. The matter of prosecution of criminal liability in the field of environmental protection is not yet implemented. Economic development should be prioritized but implementation of environmental law and policies should also be maintained and enhanced to ensure the harmony of social stability, economic prosperity, and environmental protection.

Lastly, the consumption behavior is not toward enviromnetal protection. Consumers prefer to buy cheap products and this make producers do not want to internalize environmental costs on their products. Consequently, environmental problems keep taking place and become more complicated. The focus of producers is on short-term benefit, not really interested in solving environmental problems, treatment of wastes is just for circumstantial dealing with the inspection of managing authority. Consumers, producers, and environmental regulators, therefore, must have the correct understanding of approaches and principles of environmental protection so that the environmental protection activities become more pratical, more efficient, and towards sustainable development.

4. Conclusion

The water quality in the intensive climbing perch ponds was examined in this study. The obtained results indicated that intensive cultivation of climbing perch with the use of home-made feed and industrial feed could seriously impare surface water quality. It was found that intensive ponds using home-made feed could cause more serious environmental pollution than the ponds using industrial feed because water quality indicators such as DO, BOD, COD, NH_4^+-N, and TKN were higher. The total phosphorus in the ponds used home-made feed was also significantly higher than those in the cultivating pond using industrial feed. It was obviously that the use of home-made feed could help to reuse of fish waste products, which is cost-effective but it results in serious degradation of quality of water in the river where human acitivities are heavily relied on.

Further research is needed, for example, feed consumption ratio should be studied to feed climbing perch properly thus reducing leftovers. It was highly recommended to replace home-made feed by more environmental friendly feeds for example industrial feed. The wastewater from intensive climbing perch ponds should be properly treated using natural or constructed wetlands before discharging into the receiving source. In addition, it is necessary to calculate the capacity of the river to receive amount of pollutants at which the river system could efficiently assimilate. Therefore, the amount of waste allowed to be discharged into the receiving river can be calculated and the treatment facility can be designed. Finally, promotion and strengthening the state management in the field of environmental protection in combination with propaganda to raise the awareness of environmental protection among the people towards the goal of sustainable development.

5. Acknowledgements

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6. References

[1] Ahrari, F., Eslami, N., Rajabi, O., Ghazvini, K., Barati, S., 2015. The antimicrobial sensitivity of Streptococcus mutans and Streptococcus sangius to colloidal solutions of different nanoparticles applied as mouthwashes. Dental Research Journal 12, 44-49.

[2] APHA, 1998. American Public Health Association. Standard methods for the examination of water and wastewater, 20th edition, Washington DC, USA.

[3] Boyd, C.E., 1998. Water Quality for Pond Aquaculture. Research and Development Series No. 43. International Center for Aquaculture and Aquatic Environments, Alabama Agricultural Experiment Station, Auburn University, Alabama.

[4] Lam Mỹ Lan, Kwei, L., 2004. Sử dụng nước thải từ ao nuôi cá trê lai (Clarias Macrocephalus x C. Gariepnus) làm nguồn phân bón cho lúa. Tạp chí khoa học Đại Học Cần Thơ, chuyên ngành Thủy Sản, Nhà xuất bản Nông Nghiệp.

[5] Long, D.N., 2002. Giáo trình Kỹ thuật nuôi cá nước ngọt. Khoa Thuỷ Sản, Đại Học Cần Thơ.

[6] Nga, B.T., Nghiệp, Đ.B., 2009. Đánh giá mức độ ô nhiễm của mô hình nuôi thâm canh cá trê vàng lai tại xã Giai Xuân, huyện Phong Điền, thành phố Cần Thơ. Tạp chí khoa học Đại Học Cần Thơ: 2009:12 42-50.

[7] Ngọc, L.B., 2004. Đánh giá chất lượng nước môi trường ao nuôi cá tra (Pangasius hypophthalmus) thâm canh ở xã Tân Lộc huyện Thốt Nốt Thành Phố Cần Thơ. Luận văn thạc sỹ, chuyên ngành khoa học môi trường, Đại Học Cần Thơ.

[8] Nguyên, P.Q., Y, L.H., Công, N.V., Phú, T.Q., 2014. Diễn biến một số chỉ tiêu chất lượng nước trong ao nuôi cá tra (Pangasianodon hypopthalmus) thâm canh. Tạp chí khoa học Đại Học Cần Thơ. Phần A: Khoa học Tự nhiên, Công nghệ và Môi trường: 34 (2014): 128-136.

[9] Phú, T.M., Tú, T.L.C., Hiền, T.T.T., 2006. Thực nghiệm nuôi cá rô đồng (Anabas testudineus) bằng thức ăn viên với các hàm lượng đạm khác nhau. Tạp chí Nghiên cứu Khoa học, Đại học Cần Thơ: 2006: 104-109.

[10] Phú, T.Q., 2003. Quản lý chất lượng nước ao nuôi cá nước ngọt. Nhà xuất bản Nông Nghiệp TP.HCM.

[11] Trình, L., 1997. Quan trắc và kiểm soát ô nhiễm môi trường nước. Nhà xuất bản Khoa Học và Kỹ Thuật.

[12] Tuan, N.A., Hanh, H.M., Lan, L.M., Long, D.N., Tam, Đ.H., Lanh, N.V., Thanh, L.T., 2002. Premilinary results on rearing of climbing perch (Anabas testudineus) in concrete tanks and earthern ponds. Proceeding of the 2002 annual workshop of JIRCAS Mekong delta project. November 26-28, College of Agriculture, Can Tho University, Viet Nam. Pp: 227-230. .

[13] Uyển, T.H., Nga, T.V., 2000. Bảo vệ và sử dụng nguồn nước. Nhà xuất bản Nông Nghiệp Hà Nội.

[14] Xuân, L.N., 1994. Kỹ thuật nuôi cá nước ngọt. Sở khoa học công nghệ và môi trường An Giang.