Centre for
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# Monitoring Quantity and Quality of Pangasius pond effluent

## Report of a monitoring program and recommendations for certification

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Project Report

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Project (BO-10-010-116), Reliable and measurable standards for emissions in aquaculture

This research project has been carried out within the Policy Supporting Research for the Ministry of Economic Affairs, Agriculture and Innovation, theme: Chains of sustainable products, cluster: International Cooperation.

VIỆN N.C.N.T THỦY SẢN II
RIA 2

ĐẠI HỌC CẦN THƠ

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June 2011
Project code 8140003300
Wageningen UR Centre for Development Innovation

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## Report of a monitoring program and recommendations for certification

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June 2011
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The quantity and quality of pangasius pond effluent was monitored by means of monthly sampling during a study conducted on four striped catfish farms located in the Mekong Delta, Vietnam. The study was undertaken to test the practical implications of the standards and guidelines with regard to catfish pond effluent that are at present developed by various certification programs for striped catfish production in Vietnam. The results showed a great variability twelve pangasius pond within the samples that were taken during one period of partial pond draining and refilling. The consequences of such variability with regard to the certification standards and guidelines are discussed and recommendations are given.

**Photos**
Cover and pages 7 and 8: Peter G.M. van der Heijden
Page 8: Marnix Poelman

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# Executive summary

The rapid growth of pangasius production in Vietnam has created concerns on the environmental impact of this industry. Certification programs are developed at present. To minimise the input of extra nutrients into the Mekong River system the standards of these programs include conditions with regard to the quality of pangasius pond effluents, especially the Total Nitrogen (TN) and Total Phosphor (TP) levels, in comparison to the levels in the water of the Mekong River. To test the implementation and practical implications of the standards and the guidelines of certification programs regarding the monitoring of the quality of the effluent a study was conducted on four pangasius farms located in three provinces in the Mekong Delta, Vietnam. Using a simple method described in this report the quantity of the water flowing through 12 ponds (three ponds per farm) during a catfish production cycle was estimated. Samples of incoming water and of pond effluent were taken monthly at various moments during a period of partial draining and pond re-filling. The samples were analysed for Total Nitrogen (TN) and Total Phosphorus (TP) content. The results showed that the variability  of the TN and TP content of the samples taken at various moments during one partial draining and refilling period was large (SD > 100% in 44% of the case). In one-third of the cases the average TN content of the incoming (Mekong River) water was higher than the average TN content of the pond effluent. One of the conclusion is that monitoring of TN and TP levels based on one sample taken during a partial draining or re-filling period does not give reliable results. One of the recommendations of this report  is that for water quality monitoring purposes samples should be taken at 5 or 6 times at different moments during a partial draining and refilling period. Growing participation of Vietnamese pangasius farms in certification programs will have consequences for training of farm managers and for the capacity to analyse the large number of water samples that will result from large-scale participation in certification programs in the provinces concerned.

# 1 Introduction

The Vietnamese production of striped catfish, *Pangasianodon hypophthalmus* has grown in the past decade to over 1 million metric tons. Most of the striped catfish production takes place in ponds that are located in the Mekong delta region. Major part of the production is processed and exported as frozen filets to over 100 countries. The state of pangasius farming practices has been described in Lam T. Phan et al (2009)[1]. During the production phase the pond water is partly renewed on a regular basis (almost daily during the latter part of the 5-7 months production cycle). Sludge is removed from the pond bottom in preparation of each production cycle and also once or more often during the production cycle. In various articles and media concerns have been raised about the environmental impact of the discharge of pond effluent and sludge on the Mekong River. The pollution caused by pangasius farming and processing has been assessed by Pham Thi Anh et al (2010)[2].

Various organizations are developing norms and standards in collaboration with the Vietnamese government and the pangasius producers to stimulate and improve environmental friendly production of pangasius. Farms that can prove that they are able to produce according to the norms and standards receive a certificate and label that shows that the norms and standards are adhered to. Part of the standards relate to the quality of the pond effluent.

In 2010 a project named 'Reliable and measurable standards for emissions in aquaculture BO-10-010-116' was carried out with funding from the Policy Support Cluster International program of the Dutch Ministry of Economic Affairs, Agriculture and Innovation. The project was conceived to assist the various programs and projects in Vietnam that have developed (or are in the process of development) standards for emissions from pangasius ponds. Examples of such programs are the Best Aquaculture Practices (BAP) as program of the Global Aquaculture Alliance and the Aquaculture Stewardship Council (ASC). The objective was to develop simple indicators and test their practical applicability in an effluent monitoring program on a small number of Vietnamese striped catfish farms. Based on the experiences obtained in this monitoring test run, practical advice on the measurement of the waste water from pangasius ponds was formulated.

The study was executed by staff of three organizations of the Wageningen University & Research Centre (the Netherlands), the Research Institute for Aquaculture nr. 2 (RIA2) and the Department of Freshwater Aquaculture of Can Tho University (CTU). RIA2 and CTU staff contacted and selected the pangasius farm owners and instructed the farm managers who collaborated in this study. The RIA2 and CTU staff also measured the exact dimensions of the fish ponds, collected the logbook data on water exchange that were maintained by the farm managers and sampled and analyzed the incoming and discharge water.

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[1] Lam T. Phan, Tam M. Bui, Thuy T.T. Nguyen, Geoff J. Gooley, Brett A. Ingram, Hao V. Nguyen, Phuong T. Nguyen, Sena S. De Silva. *Current status of farming practices of striped catfish, Pangasianodon hypophthalmus, in the Mekong Delta, Vietnam*. Aquaculture 296 (2009) 227 – 236.

[2] PhamThi Anh, Carolien Kroeze, Simon R. Bush and Arthur P.J. Mol. *Water pollution by Pangasius production in the Mekong Delta, Vietnam: causes and options for control*. Aquaculture Research (2010) 1 - 21.

# 2 Methods

Both RIA2 and Can Tho University staff selected two pangasius farms from the group of farmers they have regular contact with. The farms were located in Vinh Long (2), Dong Thap and Hau Giang provinces and can all be considered as big farms (> 5 ha). Of each farm three ponds were monitored in this study, bringing the total number of monitored ponds to 12. Of each pond the volume was estimated, taking the slopes into consideration. Fixed rulers that indicate water depth were placed in each pond.

**Photo 1. Ruler for recording pond water level changes resulting from draining and filling.**

Most farm managers regularly exchanged part of the pond water by means of draining part of the pond water and refilling it with river (or canal) water. Water exchange volumes were estimated from daily records kept by farm managers or technicians of pond water levels before and after draining and re-filling.

Farms were visited by RIA2 and CTU staff once/month to collect the records on water exchange and to sample incoming water and pond effluent. Two farms were visited and sampled 6 times during this study (April –September). The other two farms were sampled 6 times in the period July – December. While water was drained from a pond three effluent samples were taken; the first shortly after opening the gate, the second in the middle of the draining period and a third towards the end of the draining period. A draining period typically lasted from 45 minutes to 3 hours. While the pond was re-filled a sample of the incoming water was taken twice: shortly after start and towards the end of the re-filling period. The water samples were stored in an ice box and the Total Nitrogen (TN) and Total Phosphor (TP) content were determined in the laboratories of RIA2 and CTU. Staff of RIA2 analysed the samples using titration when TN was > 1 mg/l, and used the spectrophotometric method when TN was < 1 mg/l. Can Tho University applied the spectrophotometric method for all water samples.

Of each pond the quantity and number of fish stocked, the quantity of fish harvested and the feed load was recorded. For computation of the Total Nitrogen input during a fish production cycle the protein content of the feeds as provided by the manufacturer were used. To compute the total Phosphor input a P-level of 0.95% was assumed for all feeds. The Nitrogen and Phosphor loss to the environment was estimated as being the difference between the Nitrogen and Phosphor input into the system (by means of feeding) and the total amounts of Nitrogen and Phosphor retained in the fish. The quantity of Nitrogen and Phosphor retained in the fish was estimated to be 25.6 gr N and 4 gr P per kg fish, using a model developed by Schneider (2006)[3] which was verified by published data from previous studies (Yi, 2004)[4].

To estimate the quantity of Nitrogen and Phosphor that was discharged to the environment as result of regular water exchange and pond drainage during fish harvest the total quantity of water that was drained during a production cycle was multiplied with the difference between the average TN and TP levels of the samples taken from the drainage water minus the average TN and TP levels of the water samples taken during re-filling the ponds. The average TN and TP levels in the monthly samples of incoming water and of pond effluent were assumed to be representative for all the water that was exchanged during the month the sample was taken. For the months of the production cycle in which no water samples were taken the samples of the month that was nearest to the un-sampled time period was assumed to be representative also for the un-sampled period. For example, if ponds were stocked in March, harvested in December and sampled from May to September than the TN and TP content of the samples taken in May were assumed to be representing also the situation in March and April, and the TN and TP content of the samples of September were assumed to be representing the situation in October, November and December.

The total quantity of water that was drained during a production cycle was estimated from the dimensions of the pond and the daily records of the pond water level before and after draining and after filling. A significant part of the Nitrogen and Phosphor loss is in the sludge that settles on the pond bottom and that is removed in most cases several times during and after the fish culture cycle. No attempts were made to estimate this undisclosed part of the discharge directly .

The data were analyzed using the functions available in Microsoft Excel program (Office 2000).

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[3] Schneider, O. Fish waste management by conversion into heterotrophic bacteria biomass. (2006) PhD Thesis, Wageningen University, The Netherlands
ISBN: 90-8504-413-8.

[4] Yi, Y., D.R. Yuan, N.T. Phuong, T.Q. Phu, C.K. Lin, and J.S. Diana. 2004. Environmental impacts of cage culture for catfish in Hongngu, Vietnam. In Twenty-first annual technical report, ed. R. Harris, and EgnaH Courterl, 157–168. Oregon State University, Oregon, USA: Aquaculture CRSP.

# 3 Results

The size and volume of each pond, the length of the production cycle and the estimations of the total water exchange, fish stocking and harvesting data and feed consumption per pond for the fish production cycle that was monitored are summarized in Table 1. The average length of the production cycle was 206 days. Table 2 shows the estimates of the total Nitrogen and Phosphor input and the quantities retained in the fish. The difference between the total input and the quantity retained in the fish (called Excess in Table 2) is released to the pond water and pond sediments. To what extend pond effluent and the sediments contribute to the pollution of the Mekong River depends on the destination and treatment of the discharged water and the pond sediments (sludge). One of the farms that took part in this survey used the effluent and sludge to fertilize agricultural fields and orchards. (Note that an unknown quantity of Nitrogen will never reach the environment outside the pond but will disappear as Nitrogen gas in the atmosphere as result of nitrification and denitrification processes that take place in the ponds.) In this study monitoring only took place on pond level and not on a farm level. Therefore the input and output of ponds may differ from the total farm data, since post discharge treatments are not considered in the study.

There was a significant variability in TN levels of the incoming water, not only between sample dates and between farms but also between the first and second sample taken during one filling period.

This is illustrated with the following results of analysis of the water that entered a pond from the nearby river:

| | |
|---|---|
| TN (mg/l) after start of filling period | 1.919 |
| TN (mg/l) towards end of filling period | 0.785 |
| TP (mg/l) at start of filling period | 1.708 |
| TP (mg/l) towards end of filling period | 0.525 |

A similar variability was found between the first, second and third sample taken during one period of pond draining. This is illustrated with the following results of analysis of 3 water samples taken from the same pond at the beginning, in the middle and towards the end of a draining period:

| | |
|---|---|
| TN (mg/l) after start of draining period | 4.031 |
| TN (mg/l) in middle of draining period | 3.444 |
| TN (mg/l) at the end of draining period | 0.854 |
| TP (mg/l) after start of draining period | 2.068 |
| TP (mg/l) in middle of draining period | 0.385 |
| TP (mg/l) at the end of draining period | 0.813 |

In 44% of the cases the standard deviation of the TN levels was >100% (Figure 1).

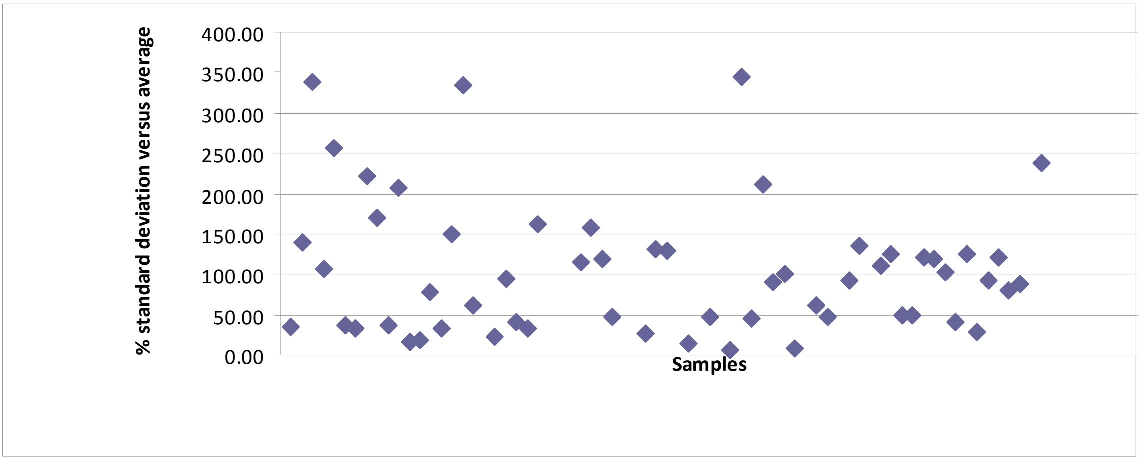

**Figure 1. Standard deviation of TN of effluent within one discharge period (3 samples/period)**

In 33% of the cases the average TN content of the effluent was *lower* than the average TN content of the incoming water (Figure 2).

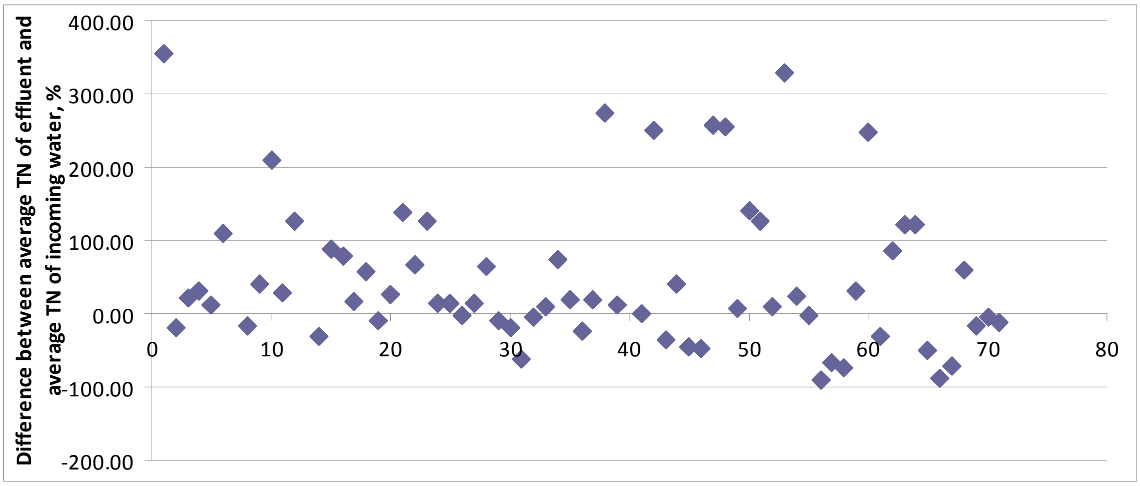

**Figure 2. Difference between average TN content of effluent and average TN content of incoming water on the same day.**

Using the difference between average TN and TP levels of the pond effluent and of the incoming water and the estimated total volume of water drained in each sampling month the amount of Nitrogen and Phosphor that left each pond during regular partial draining was computed (two most right columns of Table 2). Note that in several cases the values are negative, resulting from a number of samples with higher TN and TP levels of the water let in from the river or canal than the average TN and TP levels in pond effluent.

# 4 Conclusions and recommendations

This study can be seen as a trial run for monitoring effluent quantities and effluent quality (especially TN and TP levels). Based on this trial and the analysis of the data the following conclusions and recommendations were formulated:

### *Relating to assessment of water quantities*

The method used to assess volume of water exchanged during a culture cycle (a fixed ruler in each pond and recording of pond water level changes during each filling or draining) proved to be easy to perform in practice and is believed to be reliable as long as water levels are recorded in a consistent and detailed manner.

### *Relating to timing and frequency of sampling*

Our study aimed to generate recommendations with regard to simple but scientifically reliable procedures and indicators for pollution resulting from fish farming activities. The timing of the sample taking during a filling or draining period was a cause for great variability of the TN and TP concentration of pond effluent and of incoming water. Depending on whether one compared the difference between the TN or TP content of a first, second or third sample of the effluent and the TN or TP content of the first or the second sample of the incoming water, the difference could be positive, zero or negative. The conclusion that follows from this is that in case only one sample is taken from inlet water and one sample from the pond effluent, the result in terms of the difference between TN and TP concentration in these two samples being an indicator of the pollution (N or P) added to the water as result of fish culture activities is unreliable and largely depending on chance (related to the timing of the sample taking).

Our study does not allow any conclusions on whether for farm monitoring purposes the sampling frequency of once/month should be increased or can be decreased. For such conclusions an additional study is required. However, it seems logical to increase sampling frequency in the last 2 months of the cycle because most feed is given in the last part of the production cycle and the highest TN and TP levels in the effluent can be expected.

### *Relating to the effect of suspended solids*

Suspended solids (SS) levels of intake and discharge water affect TN and TP levels. Factors that influence SS levels of pond inlet water or discharge water (i.e. rain fall, tidal influence, nearby dredging activities, opportunity for solids to settle, etc.) have to be taken into consideration when farm or pond effluent is monitored.

### *Relating to the reliability of the estimates of total Nitrogen and Phosphor that leave the ponds dissolved in the effluent*

The results in the two columns on the right side of Table 2 are highly irregular and do not seem to follow a logical pattern. A negative value in this column is the result of (very) high TN and TP levels in two or three samples of the water that entered the ponds. A small number of samples with such high levels can cause a negative value of the total amount of N and P that is discharged during the complete fish production cycle.

The high variability between the samples taken during one filling or one draining period and the high TN (> 30 mg/l) and TP (> 3 mg/l) levels measured in part of the samples resulted in estimates of the total amounts of N and P leaving the ponds during the whole production cycle that are not reliable (Table 2, two columns on right side). The negative values in these two columns are the result of average TN and TP levels in effluent being lower than the TN and TP levels of the river water that entered the pond on that same day. One could conclude from these negative values that passing river water through pangasius ponds contributed to the cleaning of the water in the Mekong River by reducing the N and P levels, but one could question if such conclusion is justified. The method that was used in our study was not refined enough for making a quantitative assessment of nutrient discharge of pangasius ponds.

### *Relating to future effluent monitoring in the frame of fulfilling certification requirements and standards*

Certification programs have standards and in some cases do recommend a certain monitoring protocol (sample frequency, etc.) but the variation between individual farms in layout, location, water source and (water) management is large and has to be taken into consideration. See also the next paragraphs. Whether a farm is located within or outside the zone experiencing tidal influence has a significant impact.

Certification standards describing a monthly monitoring demand should consider the practical implications and verifiability of the results. In many cases the percentage of the standard error of the average is higher than the allowed percentage of difference between the influent and effluent.

For each farm to be monitored a logbook should be designed that is tailor-made to the farm situation and to the capacity of the staff members involved in the monitoring. Such a logbook can be based on the protocol and the recommendations of this study.

We recommend that to increase the reliability a water sample is taken at least 5 to 6 times during a filling or draining period. To reduce time and cost of analysis the samples should be pooled before the mixture is analyzed. Sampling may be done two to three times/month in the last two months of the production cycle.

Regular sampling and water analysis in a laboratory proved to be rather costly and time consuming. If for complying with certification programs water sampling, storage and even analysis is to be done by non-scientists, training and awareness raising about the correct and uniform procedures to be followed will be necessary.

In case farmers have no possibility to have water samples analyzed before the inspection officer's visit, it is recommended they collect samples bi-monthly and store them in the refrigerator.

If a significant number of fish farms is going to take part in certification schemes extra capacity for analyzing the water samples will be needed. The local network of (provincial) laboratories may have to be strengthened to answer the future capacity needs.

**Pangasius being fed.** Photos: P.G.M. van der Heijden

**Harvest of Pangasius ponds.** Photos: Marnix Poelman (above) and Peter G.M. van der Heijden

**Table 1. Pond dimensions, length of production cycle, stocking and harvesting data and total volume of water exchanged during the monitored production cycle of each pond.**

| Farm | Pond no. | Surface area, $m^2$ | Pond volume, $m^3$ | Production cycle (days) | Water exchanged during production cycle, $m^3$ | Weight of fingerlings stocked, kg | Number of fingerlings stocked | Weight of fish harvested, kg | Number of fish harvested |
|---|---|---|---|---|---|---|---|---|---|
| **A** | **1** | 1500 | 6,011 | 197 | 116,457 | 1641 | 86,134 | 47427 | 46,045 |
| | **2** | 1480 | 6,251 | 197 | 95,078 | 1601 | 84,025 | 49369 | 51,967 |
| | **3** | 1440 | 6,094 | 197 | 109,224 | 1656 | 86,916 | 50751 | 52,321 |
| | | | | | | | | | |
| **B** | **1** | 3496 | 12,720 | 192 | 267,719 | 2321 | 110,242 | 74,082 | 77,170 |
| | **2** | 3496 | 12,720 | 192 | 216,380 | 2346 | 111,434 | 74,616 | 80,230 |
| | **3** | 3496 | 12,720 | 192 | 214,280 | 2261 | 107,413 | 78,545 | 80,560 |
| | | | | | | | | | |
| **C** | **1** | 5995 | 24,000 | 214 | 2,895,323 | 27,342 | 515,896 | 340,560 | 360,381 |
| | **2** | 6920 | 30,448 | 163 | 2,522,198 | 17,267 | 454,387 | 316,000 | 324,103 |
| | **3** | 9217 | 41,476 | 198 | 4,756,847 | 46,240 | 711,390 | 364,000 | 374,486 |
| | | | | | | | | | |
| **D** | **1** | 3400 | 14,000 | 280 | 766,930 | 5,781 | 208,702 | 164,464 | 187,832 |
| | **2** | 3000 | 12,000 | 226 | 567,450 | 4,485 | 159,000 | 66,002 | 88,563 |
| | **3** | 8000 | 32,000 | 229 | 1,476,419 | 10,643 | 532,146 | 265,523 | 323,013 |

**Table 2. Amount of feed, Nitrogen and Phosphor provided in the feed to each pond, amount of Nitrogen and Phosphor retained in the fish, and the difference between these values (excess) which is released to the environment.**
Last two columns: TN and TP discharged during whole production cycle, based on water volume estimates and on differences between average TN and average TP levels in samples of effluent and inlet water.

| Farm, pond nr. | Feed provided, kg | Nitrogen supplied with feed, kg | Nitrogen retained in fish, kg | N Excess, kg | Phosphor supplied with feed, kg | Phosphor retained in fish, kg | P Excess, kg | TN discharged in effluent, kg | TP discharged in effluent, kg |
|---|---|---|---|---|---|---|---|---|---|
| **A, 1** | 80,920 | 3,295 | 1,172 | 2,123 | 769 | 183 | 586 | 92.7 | 3.0 |
| **A, 2** | 77,865 | 3,195 | 1,223 | 1,972 | 740 | 191 | 549 | 192.1 | 16.7 |
| **A, 3** | 81,360 | 3,359 | 1,257 | 2,102 | 773 | 196 | 577 | 151.5 | 19.2 |
| | | | | | | | | | |
| **B, 1** | 114,555 | 4,609 | 1,837 | 2,772 | 1,088 | 287 | 801 | 255.2 | 58.7 |
| **B, 2** | 117,440 | 4,766 | 1,850 | 2,916 | 1,116 | 289 | 827 | 40.2 | -18.4 |
| **B, 3** | 118,065 | 4,776 | 1,953 | 2,823 | 1,122 | 305 | 817 | -16.9 | -17.8 |
| | | | | | | | | | |
| **C, 1** | 578,952 | 24,918 | 8,018 | 16,900 | 5,500 | 1,253 | 4,247 | 62,459.8 | 7,586.5 |
| **C, 2** | 507,000 | 21,740 | 7,648 | 14,092 | 4,817 | 1,195 | 3,622 | -262,001.9 | 6,572.2 |
| **C, 3** | 601,000 | 26,059 | 8,135 | 17,924 | 5,710 | 1,271 | 4,439 | 112,391.3 | 8,807.6 |
| | | | | | | | | | |
| **D, 1** | 269,240 | 11,769 | 4,062 | 7,707 | 2,558 | 635 | 1,923 | 7,724.1 | 299.4 |
| **D, 2** | 105,450 | 4,586 | 1,575 | 3,011 | 1,002 | 246 | 756 | -4,058.1 | -312.1 |
| **D, 3** | 414,920 | 18,110 | 6,525 | 11,585 | 3,942 | 1,020 | 2,922 | -24,088.0 | 462.9 |

Various programs are developing certification standards for striped catfish (pangasius) production in Vietnam. To test the practical implications of the standards and guidelines with regard to the composition of the pond effluent, a study was conducted during which quantity and water quality of effluent of twelve pangasius ponds was monitored. Monthly samples analysed for total Nitrogen and total Phosphorus levels showed a great variability, also within a series of samples taken at various moments during one period of partial pond draining and refilling. The consequences of such variability with regard to the certification standards and monitoring guidelines are discussed and recommendations are provided.

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