

EFFECT OF FISH CAGE CULTURE ON WATER QUALITY : A CASE STUDY  
OF CHI RIVER AND YANG RIVER , ROI ET PROVINCE

ผลกระทบของการเลี้ยงปลาในกระชังต่อคุณภาพน้ำ :  
กรณีศึกษาแม่น้ำชีและแม่น้ำยัง จังหวัดร้อยเอ็ด

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received : October 12, 2008

accepted : March 15, 2009

## Abstract

This study was aimed to determine effect of fish cage culture on water quality of Chi River and Yang River in Roi-Et Province. The water samples were collected from each river; at the fish cages, 500 m upstream and 500 m downstream adjacent to the cages. The samples were collected during different seasons of the year; April 2007, July 2007, October 2007 and January 2008, representing the hot, early rainy, late rainy and cool seasons, respectively. Physiochemical properties of the water were analyzed either in the field instantly or in the

laboratory afterward. The results showed that comparing between Chi River and Yang River, some parameters on water quality; sediment, pH and organic matter, were significant difference ( $p < 0.05$ ), however, on some parameters; total nitrogen (TN) and total phosphorus (TP) were not. Furthermore, comparing among different seasons, these parameters; sediment, pH, TN, TP and organic matter, were also significant different. Then again, comparing among sampling stations; pH and % organic matter were different, except the sediment, TP and TN. The results indicated that fish

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cage culture did cause some changes in some parameters of the water quality. Yet, those changes were still within the standard. Thus, it can be concluded that the fish cage culture in Chi River and Yang River had some impacts but were not giving any significant impact toward the water quality of the rivers.

**Keywords:** Water quality, Fish cage Culture, Chi river, Yang river

### บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อระบุผลกระทบของการเลี้ยงปลาในกระชังต่อคุณภาพน้ำ ซึ่งเป็นกรณีศึกษาในแม่น้ำชีและแม่น้ำยัง จังหวัดร้อยเอ็ด ตัวอย่างน้ำถูกเก็บจากแม่น้ำ ๆ ละหนึ่งสถานี ๆ ละสามตำแหน่ง คือ จากบริเวณกระชังปลา 1 จุด, จากบริเวณเหนือลำน้ำจากกระชังปลา 500 เมตร 1 จุด และ จากบริเวณใต้ลำน้ำจากกระชังปลา 500 เมตร 1 จุด นอกจากนี้ตัวอย่างน้ำได้ถูกเก็บจากจุดเก็บตัวอย่างในช่วงเวลาต่าง ๆ ตามฤดูกาล คือ ฤดูร้อน ต้นฤดูฝน ปลายฤดูฝน และฤดูหนาว ในเดือนเมษายน 2550 เดือนกรกฎาคม 2550 เดือนตุลาคม 2550 และ เดือนมกราคม 2551 ตามลำดับ ตัวแปรที่เกี่ยวข้องกับคุณภาพน้ำได้ถูกวิเคราะห์ โดยมีทั้งการวัด ณ จุดจัดเก็บ และการนำมาวิเคราะห์ในห้องปฏิบัติการ ผลการศึกษาปรากฏว่าในบางตัวแปร เช่น ค่าความเป็นกรด-ด่าง และร้อยละของอินทรีย์วัตถุ ในสองแม่น้ำนั้น มีความแตกต่างกันอย่างมีนัยสำคัญ แต่ในบางตัวแปร เช่น ผลรวมไนโตรเจน และผลรวมฟอสฟอรัส นั้นไม่แตกต่างกัน แต่หากเปรียบเทียบผลการวิเคราะห์ของตัวอย่างน้ำที่เก็บต่างฤดูกาลนั้น ค่าค่าความเป็นกรด-ด่าง ผลรวมไนโตรเจน ผลรวมฟอสฟอรัส และร้อยละของอินทรีย์วัตถุนั้น มีความแตกต่างกันอย่างมีนัยสำคัญ แต่หากเปรียบเทียบระหว่างตำแหน่งการจัดเก็บแล้ว มีตัวแปรที่แตกต่างอย่างมีนัยสำคัญ คือ ความเป็นกรด-ด่าง และร้อยละของอินทรีย์วัตถุ ส่วนค่าค่าผลรวมของฟอสฟอรัสและผลรวมของไนโตรเจนนั้นไม่แตกต่างกัน ผลการศึกษาบ่งชี้ว่า การเลี้ยงปลาในกระชังส่งผลให้เกิดการเปลี่ยนแปลงในบางตัวแปรของคุณภาพน้ำ แต่ว่าการเปลี่ยนแปลงดังกล่าวไม่เกินข้อกำหนดของ

มาตรฐานคุณภาพน้ำ ดังนั้นจึงสรุปได้ว่า การเลี้ยงปลาในกระชังในแม่น้ำชีและแม่น้ำยังนั้น มีผลกระทบต่อสิ่งแวดล้อมระดับหนึ่ง แต่ไม่มีผลกระทบต่อคุณภาพน้ำของแม่น้ำ

**คำสำคัญ:** คุณภาพน้ำ, การเลี้ยงปลาในกระชัง, แม่น้ำชี, แม่น้ำยัง

### Introduction

Chi River originates in mountainous area, gradually flows toward tableland and then into lower plain area,<sup>(1)</sup> The Chi gains its water from the average rainfall of 1,174 mm/y. Its watershed is about 49,476 km<sup>2(2)</sup> covering the following provinces: Chaiyapoom, Konkaen, Loei, Udonthani, Kalasin, Mahasarakam, Roi-Et and Yasotorn.

Yang River is a tributary of the Chi. It's watershed is about 4,145 km<sup>2</sup>, covering some parts of 3 provinces; Kalasin, Roi-Et and Yasotorn. On average, the yearly receiving water capacity is 1,590x10<sup>6</sup> m<sup>3</sup>. The highest monthly receiving water is in August at about 500x10<sup>6</sup> m<sup>3</sup>, whereas, the least monthly receiving water is in March at about 0.8 x10<sup>6</sup> m<sup>3</sup>. Majority of receiving water, about 97%, gains during rainy season<sup>(2)</sup>.

Nowadays, Fish cage culture has gained rapid popularity among farmers due to low cost of investment, relatively easy maintenance, and the surplus product from other agricultural activities could be used for fish feed and etc. The fish cage culture is wildly practiced in various rivers around Thailand including the Chi and the Yang.

In environmental perspectives, the impact of such practices should be in concern. Since, fish feed are formulated from various organic sources to gain protein, carbohydrate, fat, vitamin and minerals. These feed would be thrown into the water. The left-over feed including the excretion from the fish themselves could post serious water quality issue. Moreover, some farmers do not realize the meat-exchange-ratio of particular fish, and over feeding. The excess could also add up to the issue. If the water body could not absorb those threats, the water quality of the river could be at risk. Consequently, the overall ecology of aquatic life should be in danger.

This study takes those issues into account and aims to follow the effect of fish cage culture to the water quality of Chi River and Yang River by closely monitoring specific parameters. Various water quality parameters; physical, chemical and biological of the samples collected from stations nearby each respective fish cage were analyzed.

## Material and Methods

1. The sampling stations: there were 2 stations; Station A of Yang River and Station B of Chi River. Station A was located at Ban Takrai Nue, Tambon Kwangmeang, Salepoom District, Roiet Province. It was positioned at the latitude  $16^{\circ}02'02.50''$ N and the longitude  $103^{\circ}54'27.37''$ E.

The river at the station was 97.86 m width, and 9.50 m depth. There were 92 cages at the station with each of them was 3x3x3 (wide x length x depth) m in sizes. All of them were used to raise Nile Tilapia (*Oreochromis niloticus*). It required about 750 kg of feed/d. Station B was located at Ban Photak, Tambon Nangam, Salepoom District, Roiet Province. It was positioned at the latitude of  $15^{\circ}49'59.28''$  and longitude of  $104^{\circ}11'1.97''$ E. The river at the station was 47.72 m width and 4 m depth. There were 20 fish cages with 3x3x2.5 m in size. All of them were also used to raise Nile Tilapia (*Oreochromis niloticus*). It required about 12.5 kg feed a day.

2. Period of study: the samples were collected during April 2007 to January 2008; in April 2007, in July 2007, in October 2007, and in January 2008, representing; the hot, early rainy, late rainy and cool seasons, respectively.

3. Water sample collection: the samples were collected at 1 m. depth from the surface of the water. Immediately; each sample was stored in a 300 ml polyethylene bottle, labeled and kept in an ice box with the temperature under 4 °C. There were 3 duplicates at each site of the collection. These parameters were measured instantly in the field; temperature, conductivity, pH, salinity, and transparency. Other parameters (as shown in Table 1) were analyzed in the laboratory;

Table 1 Parameters and methods of water quality analysis

Parameters	Methods/Equipment
Temperature ( °C)	Portable Multi-Parameter Meter Model YSI no.63
Conductivity (µs/m)	Portable Multi-Parameter Meter Model YSI no.63
Salinity (psu)	Portable Multi-Parameter Meter Model YSI no.63
Transparency (cm)	Secchi disc <sup>(3)</sup>
Alkalinity (mg/L)	Titration Method <sup>(3)</sup>
Dissolved Oxygen (mg/L)	DO meter (Model YSI 52)
pH	Portable Multi-Parameter Meter Model YSI no.63
BOD (mg/L)	Azide Modification <sup>(4)</sup>
COD (mg/L)	Close Reflux method titration <sup>(4)</sup>
Ammonia (mg/L)	Phenate Method <sup>(3)</sup>
Nitrate (mg/L)	Cadmium Column Reduction Method <sup>(3)</sup>
Total Nitrogen (mg/L)	Ultraviolet Spectrophotometric Screening Method <sup>(5)</sup>
Total Phosphorus (mg/L)	Ascorbic Acid Method <sup>(3)</sup>
Total Suspended Solid (mg/L)	Dry at 103 -105°C <sup>(4)</sup>
TOC (Total Organic Carbon, ppm)	TOC Analyzer (Tekmar Dohrmann's Apollo 9000)
Chlorophyll a (mg/L)	Spectrophotometric method <sup>(3)</sup>

4. Sediment collection: Sediments at typical sites of each station were collected by using Birge-Ekman-grab, kept in each labeled plastic bag and stored in an ice box at < 4 °c. the samples were dried and analyzed in laboratory for the following parameters (Table 2).

Table 2. Parameters and methods of soil sediment analysis

Parameters	Methods
pH	Electrometry method <sup>(6)</sup>
Total Nitrogen (mg/L)	Semi – Micro.Kjeldahl method <sup>(7)</sup>
Total Phosphorus (mg/kg)	Colorimetric method <sup>(8)</sup>
%Organic Matter	Combustion method <sup>(9)</sup>

Results

Water quality

Water quality analysis of the samples collected from nearby the fish cage culture of Chi River and Yang River

Comparing temperature at Chi River and Yang River at each assigned station, their average were at 28.90°C and 27.70°C respectively, with the significant difference ( $p>0.05$ ) (Table 3) whereas the natural water's temperature were around 23-32°C.<sup>(10)</sup> It is worth mentioning that there are more water use activities, i.e. farms, fishing, community area, agriculture area, etc. in Chi River than Yang River. Those might add to the higher in temperature. Moreover, Chi River also had higher score on conductivity; at the average of 277.43  $\mu\text{S}/\text{m}$  compared with 236.92  $\mu\text{S}/\text{m}$  in Yang River. So, it is able to absorb more energy. However, these conductivities were normal since that of the natural water was generally between 150-300  $\mu\text{S}/\text{m}$ <sup>(10)</sup>.

Comparing the water samples from Chi River and Yang River, these parameters were significantly differences: alkalinity value at 54.16 and 45.00 mg/l; transparency value at 31.25 and 42.91 cm (transparency for living of sea animals 30-60 cm<sup>(10)</sup>); pH average were 7.0 and 6.6 (pH value suitable for living creatures is 5-9<sup>(10)</sup>); biological oxygen demand (BOD) value were 1.36 and 2.06 mg/L; total phosphorus (TP) were 0.14 and 0.15 mg/L, respectively (Table 3).

On the other hand, the water samples from Chi River and Yang River did not show any significant difference in the following parameters: dissolve oxygen (DO) were 7.55 and 6.59 mg/L; chemical oxygen demand (COD) value were 28.61 and 28.63 mg/L; ammonia value were 0.07 and 0.08 mg-N/L; nitrite were 0.02 mg-N/L; nitrate were 0.20 and 0.21 mg-N/L; total nitrogen (TN) were 0.10, and 0.13 mg-N/L; chlorophyll at 0.09 and 0.10 mg/L; and, total organic carbon (TOC) of river were 1.97 and 1.86 ppm, respectively. Moreover, average salinity was 0.1 psu in both rivers.

**Table 3** Water quality analysis of the samples collected from nearby the fish cage culture of Chi River and Yang River

Parameters	Rivers	
	Chi	Yang
Temperature (°C)	28.90 <sup>a</sup>	27.70 <sup>b</sup>
Conductivity (μs/cm)	277.43 <sup>a</sup>	236.92 <sup>b</sup>
Salinity (psu)	0.1	0.1
Alkalinity (mg/L)	54.16 <sup>a</sup>	45.00 <sup>b</sup>
Transparency (cm)	31.25 <sup>b</sup>	42.91 <sup>a</sup>
pH	7.0 <sup>a</sup>	6.6 <sup>b</sup>
DO (mg/L)	7.55 <sup>a</sup>	6.59 <sup>b</sup>
BOD (mg/L)	1.36 <sup>b</sup>	2.06 <sup>a</sup>
COD (mg/L)	28.61	28.63
NH <sub>4</sub> (mg/L)	0.07	0.08
NO <sub>2</sub> (mg/L)	0.02	0.02
NO <sub>3</sub> (mg/L)	0.20	0.21
TN (mg/L)	0.10	0.13
TP (mg/L)	0.14	0.15
TSS (mg/L)	0.10	0.11
Chlorophyll-a (mg/L)	72.53	84.01
TOC (ppm)	1.97	1.86

Remark: average of factors that have different significance ( $p>0.05$ ).

Water quality analysis of the samples collected during different seasons from nearby the fish cage culture of Chi River and Yang River

Among the parameters on water quality of water samples collected from different seasons, 2 parameters: TN at around 0.07–0.13 mg/L; and,

total suspended solid (TSS) at around 0.09–0.11 mg/l are not significantly difference throughout each season (Table 4).

However, some parameters; conductivity, alkalinity, pH, Nitrite, and TOC were significantly difference in each of the 4 seasons.

On the other hand, some parameters; temperature, and salinity showed the significant difference in cool, summer and rainy seasons, but, show no significant difference between the samples from the early or late rainy seasons.

Though, some parameters; transparency, BOD, and TP demonstrated significantly difference between the early or late rainy seasons or to the other seasons, but, gave no significant difference between summer and cool seasons.

Conversely, the other parameters illustrated their unique characteristics: DO of the samples gave no significant difference in summer and late rainy seasons, but gave significant difference among the rest; COD of the samples were no significant difference between late rainy and cool seasons, but were significant difference for the other seasons; Nitrate showed no significant difference between early rainy and late rainy or between summer and early rainy; and, chlorophyll-a provided the no significant difference between cool season and summer or early rainy and late rainy seasons.

**Table 4** Water quality analysis of the samples collected during different seasons from nearby the fish cage culture of Chi River and Yang River

Parameters	Seasons			
	January (cool)	April (summer)	July (early rainy)	October (late rainy)
Temperature (°C)	25.10 <sup>c</sup>	32.00 <sup>a</sup>	28.00 <sup>b</sup>	28.00 <sup>b</sup>
Conductivity (µs/cm)	173.67 <sup>c</sup>	352.22 <sup>b</sup>	382.58 <sup>a</sup>	120.26 <sup>d</sup>
Salinity (psu)	0.1 <sup>b</sup>	0.2 <sup>a</sup>	0.05 <sup>c</sup>	0.05 <sup>c</sup>
Alkalinity (mg/L)	40.00 <sup>c</sup>	73.33 <sup>a</sup>	55.00 <sup>b</sup>	30.00 <sup>d</sup>
Transparency (cm)	48.75 <sup>a</sup>	53.75 <sup>a</sup>	35.00 <sup>b</sup>	10.83 <sup>c</sup>
pH	6.4 <sup>c</sup>	6.1 <sup>d</sup>	7.0 <sup>b</sup>	7.8 <sup>a</sup>
DO (mg/L)	9.60 <sup>a</sup>	6.63 <sup>b</sup>	5.05 <sup>c</sup>	7.00 <sup>b</sup>
BOD (mg/L)	1.12 <sup>c</sup>	1.02 <sup>c</sup>	1.94 <sup>b</sup>	2.77 <sup>a</sup>
COD (mg/L)	31.71 <sup>b</sup>	15.01 <sup>c</sup>	40.40 <sup>a</sup>	27.36 <sup>b</sup>
NH4 (mg/L)	0.12 <sup>a</sup>	0.05 <sup>bc</sup>	0.10 <sup>ab</sup>	0.03 <sup>c</sup>
NO <sub>2</sub> (mg/L)	0.01 <sup>c</sup>	0.004 <sup>d</sup>	0.02 <sup>b</sup>	0.04 <sup>a</sup>
NO <sub>3</sub> (mg/L)	0.38 <sup>a</sup>	0.05 <sup>c</sup>	0.17 <sup>bc</sup>	0.22 <sup>b</sup>
TN (mg/L)	0.13 <sup>a</sup>	0.08 <sup>a</sup>	0.07 <sup>a</sup>	0.20 <sup>a</sup>
TP (mg/L)	0.04 <sup>c</sup>	0.04 <sup>c</sup>	0.10 <sup>b</sup>	0.31 <sup>a</sup>
TSS (mg/L)	0.11 <sup>a</sup>	0.09 <sup>a</sup>	0.09 <sup>a</sup>	0.09 <sup>a</sup>
Chlorophyll-a (mg/L)	103.22 <sup>a</sup>	127.09 <sup>a</sup>	34.75 <sup>b</sup>	48.03 <sup>b</sup>
TOC (ppm)	2.08 <sup>b</sup>	2.52 <sup>a</sup>	1.69 <sup>c</sup>	1.39 <sup>d</sup>

Water quality analysis of the samples collected from different spots around the fish cage culture of Chi River and Yang River

Water quality analysis of samples collected from different spots (upstream, at the cage and downstream) around the fish cage culture showed no significant difference among the samples on the following parameters; conductivity, alkalinity, transparency, pH, DO, BOD, COD, ammonia, nitrite, nitrate, TN, TSS, and chlorophyll a.

On the other hand, the temperatures at 500 m upstream (28.4°C) and at the fish cage (28.1°C) were significant differences. Interestingly, the temperature at 500 m downstream (28.38 °C) stayed in between the two and gave no significantly difference among them. TP was significantly lower at the cage (0.11 mg/L) and at downstream (0.11 mg/L) compared with that of the upstream (0.18 mg/L).

Uniquely, TOC was significantly increased

from 1.67 ppm at upstream spot to 1.91 ppm at the cage and again higher at 2.18 ppm at downstream area.

**Table 5** Water quality analysis of the samples collected from different positions (upstream, at the cage and downstream) around the fish cage culture of Chi River and Yang River.

Parameters	Stations		
	Upstream	At fish cage	Downstream
Temperature (°C)	28.40 <sup>a</sup>	28.10 <sup>b</sup>	28.40a <sup>b</sup>
Conductivity (µs/cm)	252.50	259.27	259.78
Salinity (psu)	0.10	0.10	0.10
Alkalinity (mg/L)	50.00	48.75	50.00
Transparency (cm)	36.25	37.50	37.50
pH	6.7	6.9	6.8
DO (mg/L)	7.10	6.95	7.16
BOD (mg/L)	1.59	1.78	1.76
COD (mg/L)	26.23	28.35	31.28
NH <sub>4</sub> (mg/L)	0.09	0.08	0.07
NO <sub>2</sub> (mg/L)	0.02	0.02	0.02
NO <sub>3</sub> (mg/L)	0.22	0.19	0.21
TN (mg/L)	0.15	0.09	0.11
TP (mg/L)	0.18 <sup>a</sup>	0.11 <sup>b</sup>	0.11 <sup>b</sup>
TSS (mg/L)	0.09	0.09	0.11
Chlorophyll-a (mg/L)	72.87	87.96	73.99
TOC (ppm)	1.67 <sup>c</sup>	1.91 <sup>b</sup>	2.18 <sup>a</sup>

**Sediment analysis of fish cage culture**

Sediment analysis among samples of Chi River and Yang River (Table 6) showed that

the average of nitrogen (TKN), pH, and %organic matter were significantly differences between the two rivers, except TP.



**Table 6** Sediment analyses of samples collected from fish cage culture of Chi River and Yang River

Parameters	Rivers	
	Chi	Yang
TKN (mg/L)	0.86 <sup>a</sup>	0.69 <sup>b</sup>
TP (mg/L)	3.28	3.11
pH	6.65 <sup>a</sup>	6.23 <sup>b</sup>
% Organic Matter	35.83 <sup>a</sup>	33.15 <sup>b</sup>

Moreover, sediment analysis among samples collected during typical time of the year (Table 7) illustrated that the TP and %organic matter were significantly decreased from cool season to summer and early rainy seasons. TKN was not significantly difference in cool season and summer, but that of the early rainy season was difference from the others. The pH was also significant difference among the three seasons; high in cool season, lower in early rainy season and lowest in summer.

**Table 7** Sediment analysis of samples collected during different time of the year from fish cage culture of Chi River and Yang River

Parameters	Seasons		
	January (cool)	April (summer)	July (early rainy)
TKN (mg/L)	0.83 <sup>a</sup>	0.93 <sup>a</sup>	0.56 <sup>b</sup>
TP (mg/L)	6.25 <sup>a</sup>	3.23 <sup>b</sup>	4.08 <sup>c</sup>
pH	7.23 <sup>a</sup>	5.49 <sup>c</sup>	6.61 <sup>b</sup>
% Organic Matter	42.99 <sup>a</sup>	36.06 <sup>b</sup>	24.40 <sup>c</sup>

Sediment analysis of samples collected at different spots from fish cage culture (Table 8) demonstrated that the average of TKN, and TP were not different significantly. The pH values were about the same at upstream and

downstream, however, lower at the cage. Interestingly, the % organic matter increased from 29.94 at upstream area to 35.58 at the cage and to 43.94 at downstream area, respectively.

**Table 8** Sediment analysis of samples collected at different spots from fish cage culture of Chi River and Yang River

Parameters	Locations		
	Upstream	Fish Cage	Downstream
TKN (mg/L)	0.71	0.79	0.83
TP (mg/L)	2.77	2.80	4.01
pH	6.56 <sup>a</sup>	6.29 <sup>b</sup>	6.47 <sup>a</sup>
% Organic Matter	23.94 <sup>c</sup>	35.58 <sup>b</sup>	43.94 <sup>a</sup>

## Discussion and Conclusion

### Physical water quality

Temperatures of water were significantly different in typical season. It was highest in summer, lower in rainy season and lowest in cool season which was compatible with the study of Yom River by Sujaya and Decha<sup>(11)</sup>. Transparency of the water was lower during rainy season indicated that it was affected by the high sediment in the water body, high activity from communities, animal, aquatic biota during rainy season<sup>(13)</sup>.

### Chemical water quality

The pH value was low in summer however it was increased close to neutral in rainy season due to large amount of water added to the river. Dissolved oxygen was highest in cool season but lowest in rainy season. Moreover, dissolved oxygen at the fish cages was lower than the control value (upstream and downstream). However, the parameters in the nutrient group i.e. phosphorus and nitrogen were high in rainy season but low in cool season. It could be explained that rain flow brought those nutrient down from agricultural fields or households into the rivers. This agreed with Tidaporn who studied Bangpakong River and claimed influence of land use directly such as community use, factory and animals farming etc<sup>(18)</sup>.

### Biological water quality

Chlorophyll a value was high in cool season and summer, but significantly low in rainy season.

### Soil sediment

The most obvious changed parameter was % organic matters which was significantly increased from 23.94 upstream to 35.58 at fish cages and even higher at 43.94 downstream.

### Acknowledgements

This research was supported by the Environment Research Institute of Chulalongkorn University and the Environmental Science - Interdisciplinary Program, Graduate School, Chulalongkorn University. Thank you to the Center of Excellence, Marine Biotechnology Department, Faculty of sciences, Chulalongkorn University and all the colleagues in the Environment Science class for their supports and helps during sample collections and during field studies.

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