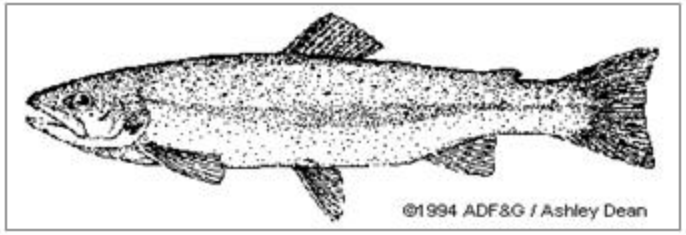
SOLID WASTES CONTROL IN AN INTENSIVE SEMI-RECIRCULATION RAINBOW TROUT FARM



Muslim, In-Bae Kim, Jae-Yoon Jo
Department of Aquaculture
Pukyong National University
Busan, Korea

YSLME

Qingdao, China

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INTRODUCTION

- Ammonia and feces: important water quality parameters in aquaculture systems.
- Solid wastes: troublesome in Recirculating Aquaculture Systems.
- Feces and uneaten feed in the system could generate additional oxygen demand, produce CO_2, ammonia, high turbidity and lower bio-nitrifying efficiency, or encourage the growth of pathogens.

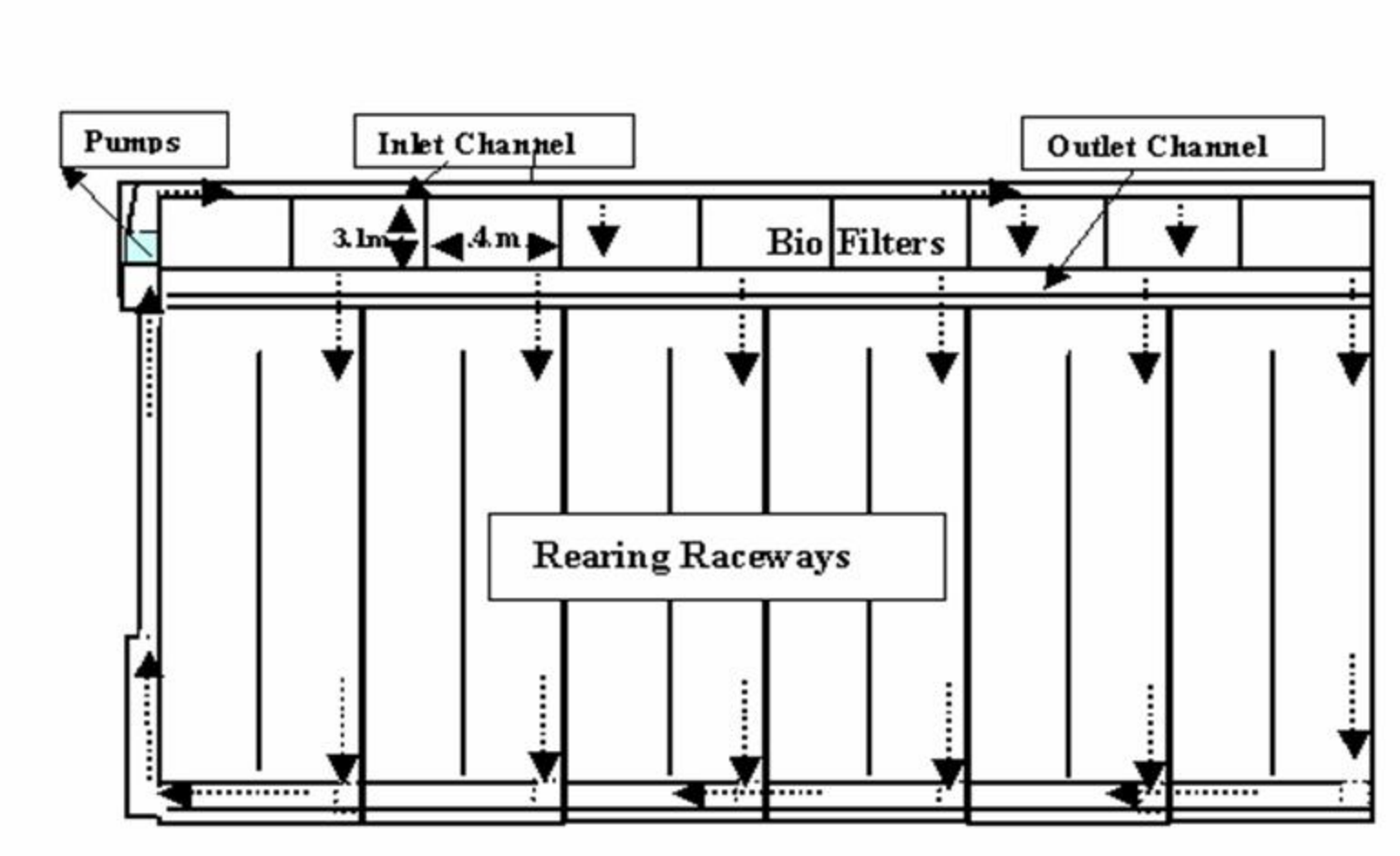
- Biofilter of Intensive Bio-production Korean (IBK) system has been operating successfully in Korea and showed the possibilities of removing TSS.

Objective

- To evaluate the efficiency of the IBK system biofilter on removal of ammonia, total suspended solids, COD and some nutrients in a semi-recirculating commercial scale rainbow trout farm
- Apply this to reduce metabolic wastes from fish farm effluent for protecting natural body of water

MATERIALS AND METHODS

- **Place: Rainbow Trout Farm in Chungri, Sangju, Korea**
- **Rearing to market size fish in a semi-recirculating raceways**
- **6 raceways: 30 m x 6 m x 1 m (D) each**
- **9 biofilter chambers: 4 x 3.1 x 1.7 m (D) each**
- **Water volume in the raceways: 1,050 m^3**
- **Standing biomass: 20 tons**
- **Feeding rate: 150-300 kg/day (48% protein)**
- **Experiment period: August-October 2004**



Schematic drawing of the tested Semi-Recirculating Rainbow Trout Farm

- **IBK biofilter**

  9 chambers: 4 m x 3.1 m x 1.7 m (D) each chamber

  Biofilter media: 1,600 corrugated plastic plates in each chamber

  Size of each plate: 63 x 127 x 1 cm (H)
- **Specific surface area: 237.8 m^2/m^3**
- **Water pumping rate into biofilter: 500 m^3/h**
- **Turn over rate: about 12 times/day**
- **Amount of make up water: 2,000 m^3/day**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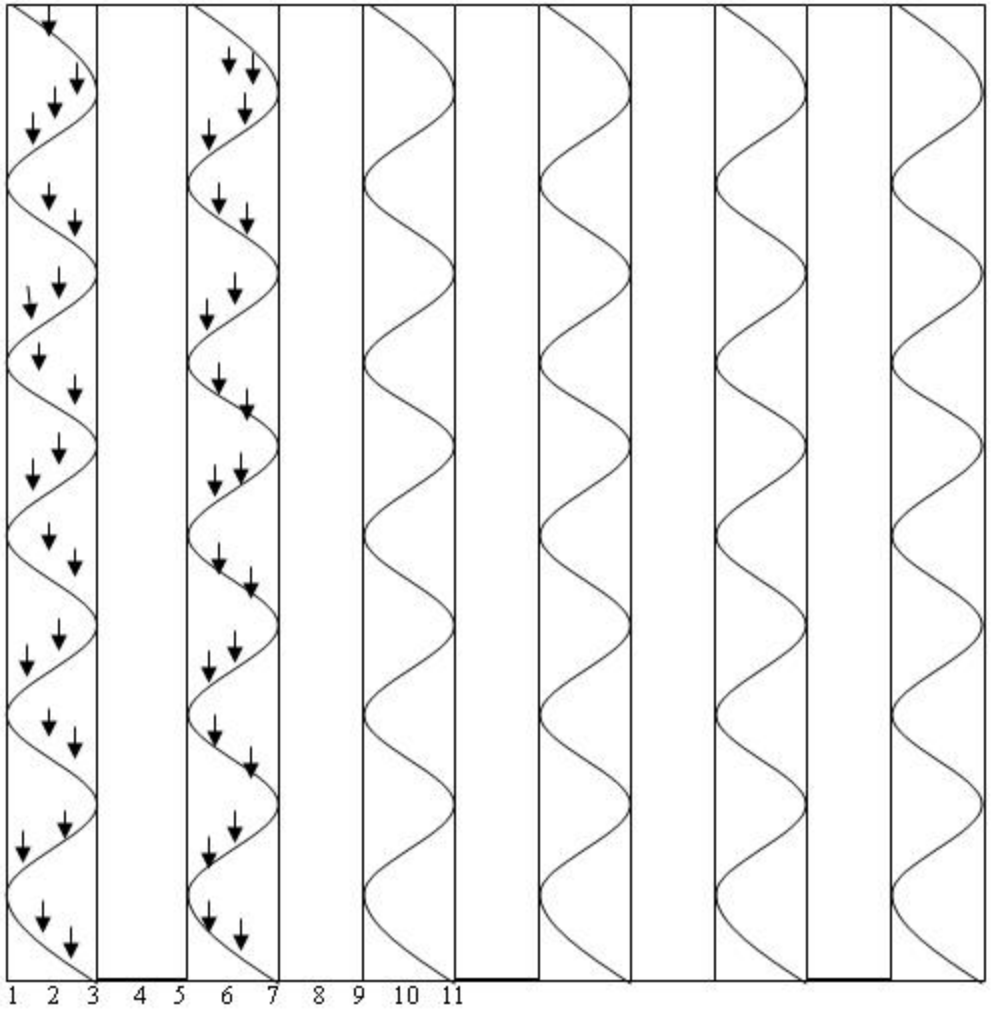
Corrugated Plastic Plates Arranged in IBK System Biofilter



- **Short distance of SS settling**

Settling area 40x more of floor space

Specific surface area 237.8m^2/m^3 (302 m^2/m^2 of floor)

1600 corrugated plastic plates per each IBK system biofilter

ANALYSIS METHODS

- **TAN: Orion-Model 720A**
- **SS: GF/C micro-fiber filter**
- **Nutrients: Ion chromatography (Dionex DX-120, USA) and spectrophotometer (OPRON-3000 Hanson Tech. Korea)**
- **COD: Potassium dichromate reflux (APHA, 1995)**

RESULTS

Removal Efficiencies of TAN

	Trial-1 August		Trial-2 September		Trial-3 early Oct		Trial-4 end of Oct	
	Before	After	Before	After	Before	After	Before	After
Mean	2.00	1.72	1.44	1.22	1.07	0.86	1.74	1.54
SD(±)	0.61	0.49	0.43	0.39	0.19	0.17	0.18	0.14
Efficiency (%)		13.76		14.97		19.82		11.68
Removal(mg/L)		0.275		0.216		0.212		0.203
Removal(g/d)		3,298		2,588		2,548		2,439
Removal($g/m^2/d$)		0.073		0.057		0.056		0.054
Removal($g/m^3/d$)		17.38		13.64		13.43		12.86

Removal Efficiencies of SS

	Trial-1 August		Trial-2 September		Trial-3 early Oct		Trial-4 end of Oct	
	Before	After	Before	After	Before	After	Before	After
Mean	0.66	0.26	1.08	0.68	1.39	0.9	1.54	0.91
SD(±)	0.17	0.114	0.2	0.087	0.242	0.129	0.147	0.154
Efficiency (%)		61.24		37.11		35.03		41.11

Removal Efficiencies of TS and (SS) in IBK Biofilter

	Before	After
Mean SD(±)	3.64 ± 0.645	0.928 ± 0.188
Efficiency(%)	74.51 (39.2)	
Removal (mg/L)	2.71 (0.6)	
Removal (kg/d)	32.5 (7.2)	
Removal($g/m^2/d$)	0.72	

Removal Efficiencies of Dissolved Nutrients

	Trial-1 August		Trial-2 September		Trial-3 early Oct		Trial-4 end of Oct	
	Before	After	Before	After	Before	After	Before	After
NO_3-N								
Mean	4.1	4.27	3.57	3.77	3.4	3.69	3.66	3.58
SD(±)	0.104	0.108	0.179	0.219	0.085	0.084	0.099	0.089
Efficiency (%)		-(4.29)		-(5.68)		-(8.44)		1.99
NO_2-N								
Mean	0.18	0.17	0.23	0.23	0.2	0.21	0.18	0.18
SD(±)	0.013	0.013	0.026	0.026	0.015	0.016	0.006	0.004
Efficiency (%)		6.1		-(0.53)		-(1.34)		-(0.49)
PO_4-P								
Mean	0.45	0.46	0.3	0.31	0.44	0.46	0.36	0.38
SD(±)	0.023	0.027	0.02	0.026	0.024	0.026	0.014	0.013
Efficiency (%)		-(0.98)		-(2.43)		-(3.89)		–(5.71)

Removal Efficiencies of COD

	Trial-1 August		Trial-2 September		Trial-3 early Oct		Trial-4 end of Oct	
	Before	After	Before	After	Before	After	Before	After
Mean	4.05	3.2	7.13	5.32	8.42	6.33	11.02	8.73
SD(±)	0.517	0.629	1.127	0.93	1.402	1.339	1.307	1.618
Efficiency (%)		21.01		25.4		24.82		20.84
Removal (mg/L)		0.85		1.811		2.089		2.297
Removal (g/h)		425.1		905.6		1,045		1,149
Removal($g/m^2/d$)		0.23		0.48		0.56		0.61
Removal($g/m^3/d$)		53.8		114.6		132.2		145.3

DISCUSSION

Nitrification process in IBK system

- TAN removal efficiency: 11.7 – 19.8%
- Daily total removal: 2,439 – 3,298 g/day
- Removal rate: 0.054 – 0.073 g/m^2/d

- Twarowska et al (1997) used a trickling filter for tilapia.
  TAN removal rate 0.33 g/m^2/d, (efficiency 64%),
  but water flow rate was only 469 L min^{-1}.
- Shnel et al (2002) used a trickling filter for grow-out tilapia
  TAN removal rate 0.16 g/m^2/d and daily removal 624-1,560 g/day
- Greiner and Timmons (1998): compared between micro bead and trickling filter on TAN treatment. The result that TAN removal efficiency: 8.6 $\pm$2.6% and 9.3$\pm$4.6% respectively. The daily TAN removal rate ranged : 0.13-0.57 g/m^2/d and 0.94-3.92 g/m^2/d respectively

Comparison of TAN Removal with Other Submerged Biofilters

Biofilter Material	Removal Rate ($g/m^3/d$)	Removal Efficiency (%)	Specific Removal Rate ($g/m^2/d$)	References
Plastic rolls	3.46	29.37	0.043	Al-Hafeth et al, 2003
Scrub pads	2.95	25.04	0.037	Al-Hafeth et al, 2003
PVC pipes	3.2	27.16	0.040	Al-Hafeth et al, 2003
Polypropylene	9.3	-	-	Ridha & Cruz, 2001
Polyethylene	8.9	-	-	Ridha & Cruz, 2001
Corrugated	6.1	-	-	Suresh & Lin, 1992
Embossed plastic plate	7.79	-	-	Kim et al, 1987
Gravel	7.05	-	-	Kim et al, 1987
Corrugated skylight	7.83	-	-	Kim et al, 1987
Pile cloth	8.38	-	-	Kim et al, 1987
Corrugated	14.33	15.03	0.060	This study

TSS Removal by IBK System Biofilter

- **Average TSS concentrations before and after IBK biofilter:**

  3.64 mg/L and 0.928 mg/L respectively
- **TSS removal efficiency : 74.5%**
- **Daily removal : 32.5 kg/day (0.7g/m^2/d)**

- **Dean (1994) rainbow trout prefer clear, cool and high quality water.**
- **Alabaster and Lloyd (1982) found that there is no evidence that concentrations of suspended solid less than 25 mg/L have any harmful effect on fisheries in the river and lake.**

- **TSS removal efficiency : 74.5%**
- **Daily removal : 32.5 kg/day (0.7g/m^2/d)**

Davidson and Summerfelt, in press: SS removal efficiencies in RAS for grow-out of arctic char (1.3 kg) and rainbow trout (0.7 kg) were 23% and 48%, treated by swirl separator system and radial-flow settler, respectively.

TSS concentrations after IBK in August (summer) and the end of October (autumn) were significantly different, caused by feed consumption.

Ladewing and Morat, 1995: Cool temperature is preferred for rainbow trout.

Dissolved Nutrients

IBK biofilter was not effective to remove dissolved nutrients, rather increased.

In August the concentrations of NO_3, PO_4, TAN were higher compared with other months. This may have been the result of increased summer time temperatures.

Nutrient leaching can occur into the water body, depending on some aspects such as temperature and re-suspension (Muslim and Jones, 2003).

Bio-available phosphorus showed an excellent linear relationship with suspended solids (Chiswell, 1995).

Bergheim et al (1993) and Heinen et al (1996) :

50 – 85% of phosphorus discharged from intensive aquaculture system is contained in the filterable or settleable solid fraction.

Thus, reducing TSS by IBK biofilter in the system is the same as reducing total nutrients in the water, even though some dissolved nutrients increase to some extent through IBK biofilter.

COD

Reducing TSS through IBK biofilter is also effective to reduce COD, because the TSS is mostly of organic matters.

COD removal efficiency ranged 20.8-25.4% with removal rate 425.1-1,149 g/h (0.47 g/m^2/d)

- **Guellil et al (2000) fractionated the organic matter of city wastewater into settleable (particulate) and non settleable (colloidal + soluble) fractions. Of the total COD, proportions of particulate, colloidal and soluble were 45, 31 and 24% respectively.**

CONCLUSION

IBK system biofilter

- **Works well in Nitrification**

  TAN removal efficiency ranging : 11.7-19.8%

  (12.9-17.4 $g/m^3/d$).

- **Effective to remove TSS**

  Removal efficiency : 74.5%,

  Removal rate : 32.55 kg/day (0.7$g/m^2/d$).

- **Effective to remove COD**

  Removal efficiency : 20.8-25.4%

  Removal rate : 425.1-1,149 g/h

  (111.5 g/m^3/d)

- **Not Effective to reduce dissolved nutrients**

  However, the concentrations of dissolved nutrients were not harmful to fish.

Acknowledgments

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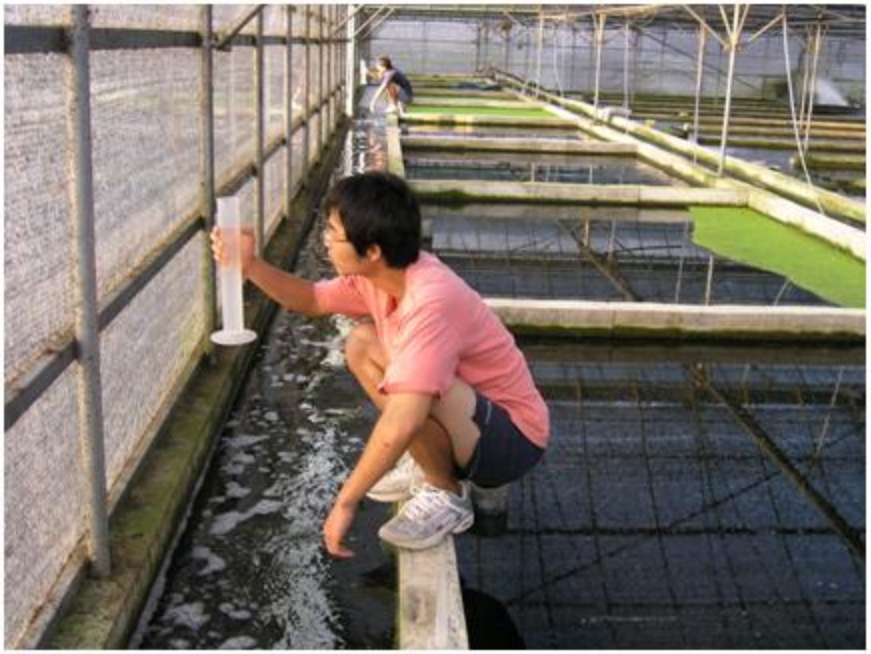
Water Sampling from IBK System Biofilter

Inlet



Outlet


Water Sampling


Set 5 min


Settleable Solids


Non Settleable Solids

Rainbow trout farm

Rainbow trout flesh

謝謝

THANK YOU