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Cost of Alternative Effluent Treatments for Catfish Production

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The potential for environmental impact of effluent discharge from aquaculture facilities is a growing concern among policy makers. Since 1974, the United States Environmental Protection Agency (EPA) has regulated discharge of pollutants to waters of the United States under authority of the National Pollutant Discharge Elimination System (NPDES) permit. In some states, the NPDES permits have been applied to effluents from aquaculture facilities. These regulations may cause farmers to consider alternative production methods for either effluent removal or reduction.

A Southern Regional Aquaculture Center project identified four potential alternatives for treating aquaculture effluents: (1) no treatment; (2) irrigation of crops with effluents; (3) constructed wetlands; and (4) filter-feeding fish stocked in ponds paired with catfish ponds. All treatment options will remove both dissolved nutrients and suspended solids. Layouts of two experimental designs are shown in figures 1 and 2.

Several experiments using these treatment technologies have been conducted, but there are no farm data available for best management practices. This fact sheet presents the costs of several alternative effluent treatment technologies. It should be noted that the present fact sheet considers only the cost of treatment, but does not account for the relative effectiveness of treatment methods. At the present time, there are no comparable data available as to whether rice fields remove more or fewer nutrients and suspended solids than constructed wetlands, nor to document conclusively the impact of filter-feeding fish. Any decisions made regarding treatment methods should combine these cost estimates with research results on the relative efficiencies of effluent removal.

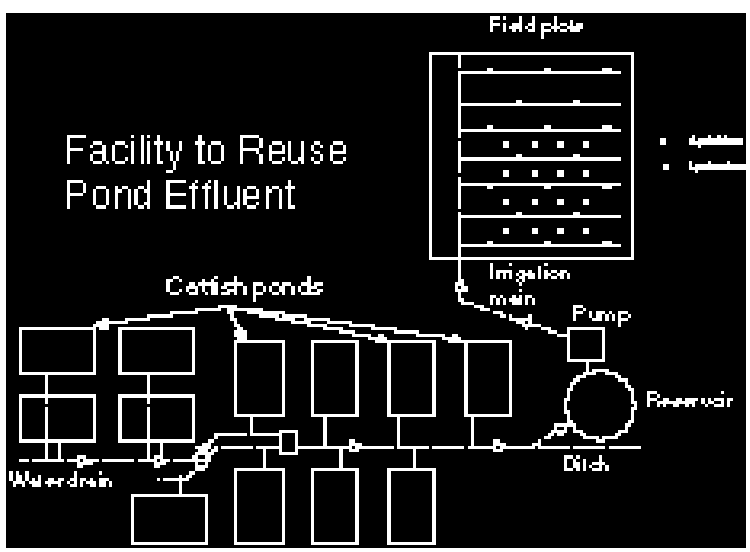

Figure 1. Integrated fish-crop production facility.
Source: Ghate et al. (1993).

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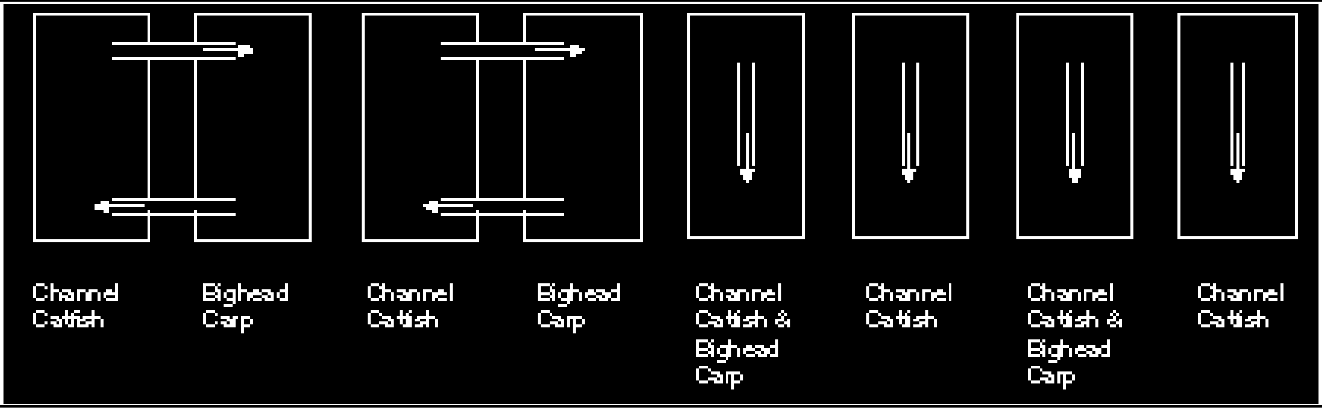

Figure 2. Experimental design for a paired-ponds system.

Two sets of adjacent ponds were connected by 4-inch water lines so that water could be pumped from one to the other. Return lines were placed at the opposite end of the ponds and water was allowed to flow back to the origin pond by gravity. Four additional ponds were equiped with pumps and water lines to circulate the water within each pond at the rate water was pumped from pond to pond in connected ponds.

Source: Griffin (1993).

It should be noted that the typical catfish production facility in the Mississippi Delta region, where most of the industry is concentrated, discharges water only rarely, once every 5 to 10 years, and is not a continuous discharge system. However, treatment options proposed consist primarily of fixed costs that will be incurred whether or not water is treated. If regulations require treatment, the costs estimated in this study will be incurred regardless of whether water is treated only at harvest time, during periods of excess runoff, or on a continuous basis.

The representative farm is assumed to have 160, 320, or 640 water acres with 20-acre ponds. (For details, see Kouka and Engle, 1994.) Water is supplied from wells. Fingerlings (7-8 inches) are stocked at 6,000 fish per acre with a 92 percent survival rate. It is assumed that fish reach a marketable size of 1.50 pounds in 180 days with a feed conversion ratio of 2:1.

Table 1 presents catfish production costs for the assumed base scenario of no effluent treatment. Breakeven prices were $0.51, $0.50, and $0.49 for the 160, 320, and 640-acre farms, respectively, while breakeven yields were 6,083, 5,927, and 5,854 lb / acre for the same farm sizes. These breakeven yields are higher than average industry yields because this analysis is based on research conducted in experimental ponds. However, these same yields are obtained on some well-managed commercial ponds. The following comparisons of costs of treating aquaculture effluents can still be applied to a commercial farm because the relative changes in costs should hold even if a particular farmer has lower stocking rates and yields than those assumed in this analysis.

The cost of irrigating crops with pond effluents is presented in Table 2. Based on Brown and Engle (1994), 1 acre of catfish

Table 1. Catfish production costs and returns with no effluent treatment, stocking rate of 6,000 fish/acre.

	Farm Size (acres of water)		
Item	**160**	**320**	**640**
	$/acre		
Investment (w/o land)	3,479	2,961	2,791
Gross Receipts ($0.70/lb)	5,796	5,796	5,796
Operating Cost	3,980	3,910	3,875
Fixed Cost	278	239	223
Total Cost	4,258	4,149	4,098
Returns	1,538	1,647	1,698
Breakeven Price ($/lb)	0.51	0.50	0.49
Breakeven Yield (lbs/acre)	6,083	5,927	5,854

Table 2. Additional costs and returns using rice irrigation to treat effluents, 320-acre farm.

Item	**Costs/Returns**
	$/acre
Revenue	
- Rice (pond acreage)	54
Cost	
- Additional cost	
Pumping	19
Cost of System	22
Net Benefits	+13
Breakeven Price ($/acre)	.50
Breakeven Yield (lbs/acre)	5,909

pond water is used for 3.5 acres of rice production. The major cost items include the cost of piping and plumbing, and an additional pumping cost. In some areas, it may be possible to construct ponds in such a way as to use gravity for irrigation, but in areas with level terrain, this additional pumping cost will be required. Some experiments have demonstrated no change in yield of catfish when water was removed for irrigation. The breakeven price estimate accounts for rice income and for reduced feeding and harvesting costs of fish when pond water is removed for irrigation. Assuming that fish yield remains unchanged by irrigation practices, breakeven price would be $0.50 and breakeven yield would be 5,909 lb / acre for a 320-acre farm.

Table 3 presents investment and operating costs for both lined and unlined constructed wetlands systems for the three farm sizes considered. Maintaining the existing land base means reducing production capacity. Wetland acreage needed is estimated to treat 5 percent of pond volume and equals 0.2 and 0.1 acres of wetland for each pond acre for surface and subsurface flow wetlands systems, respectively. Breakeven prices were $0.56, $0.55 and $0.54 and breakeven yields were 6,669, 6,504 and 6,427 lb / acre for the 160, 320, and 640-acre farm, respectively, maintaining the current base acreage. It should be mentioned that no significant variability is observed in breakeven prices and yields between the use of current base and additional acreage.

These estimates do not include any potential value from the wetlands vegetation itself, but they do take into account an opportunity cost of land represented by a lost income of $347 / acre for rice production. If revenues can be generated by the wetlands area itself, breakeven prices would decrease. For example, the wetland area would have to generate $403 / acre in revenues for breakeven prices to be equivalent to that of no treatment. By comparison, rice revenues generally averaged $347 / acre in Arkansas. When stocking density was increased to 8,000 fish / acre, fish revenues were still not high enough to offset the cost of contructing and operating wetlands.

The costs of stocking a pond with filter-feeding fish as a treatment for aquaculture effluents are presented in Table 4 for a 320-acre farm. Using this treatment method requires removing one pond from catfish production for every pond remaining in production. Pumps are located so as to move the majority of the water from the catfish pond through a bighead carp pond (see Griffin, 1993, for details on the system). The lost profits that would have resulted from such a system constitute a major cost to this alternative. However, this cost is partially offset by revenues from bighead carp (filter-feeding fish) production and the higher catfish stocking density of 8,000 fish / acre. The revenues from bighead carp may range from $372 to $496 per acre (yield ranging from 600 to 800 lb / acre sold at a price of $0.62 / lb) and would cause average breakeven price to equal $0.53 / lb for the 320-acre farm, assuming that production parameters remain unchanged.

In summary, catfish production costs would be increased by $0.00 to $0.05, and additional production required to break even would range from 0 to 576 lb / acre if mandatory effluent control measures such as those described here were enforced (Table 5).

Table 3. Investment and operating costs for constructed wetlands.

	Farm Size (ac.)	Wetland Size (ac.)	Investment Cost: Unlined	Investment Cost: Lined	Operating Cost[b] ($)	Breakeven Pr. $/ac	Breakeven Yield lb/ac
A.[a]							
	160	26	800,832	1,123,249	1,654	.56	6,669
	320	54	1,655,103	2,311,254	3,065	.55	6,504
	640	108	3,301,355	4,595,558	5,827	.54	6,427
B.[a]							
	160	32	984,036	1,378,170	1,961	.56	6,666
	320	64	1,959,903	2,734,510	3,559	.55	6,502
	640	128	3,910,213	5,440,495	6,790	.54	6,426

[a]A=Current land base and B=additional acreage.

[b]Includes pumping, levee maintenance, vegetation harvest, general overhead and depreciation. An opportunity cost of $347/acre (5,500 lb/acre of rice at $6.30/cwt) is included in the determination of breakeven prices and yields.

Table 4. Additional costs and returns using paired ponds to treat effluents, 320-acre farm.

Item	Costs/Returns
	$/acre
Revenue	
- Bighead	434
Cost	
- Additional cost	
Pumping	8
Depreciation	19
Feeding	226
- Reduced Income	1,932
Net Benefits	-1,751
Breakeven Price ($/acre)	.53
Breakeven Yield[a] (lbs/acre)	8,429

[a]Breakeven yield was very high mostly due to a high stocking density of 8,000 fish/acre (average yield of 11,040 lb/acre).

Regulators clearly need to take into account the wide range of costs of these alternatives to avoid imposing regulations that would have a major adverse impact on the aquaculture industry.

Note: Data presented are the result of experiments and may not reflect commercial production.

Table 5. Additional cost per pound of fish produced under alternative treatments and additional production required to break even[a].

Item	No Treatment	Constructed Wetlands	Paired Ponds	Rice Irrigation
Cost ($/lb)	0.00	0.05	0.03	0.00
Yield (lb/acre)	0	576	395	0

[a]This assumes no change in yield of catfish due to treatment options. Research literature has conflicting results as to whether on not these types of treatments will affect fish yield. Comparison is based on stocking density of 6,000 fish/acre for all considered options.

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