

IX: ENVIRONMENTAL IMPACT OF POND FISH CULTURE

Sustainable pond fish farming is dependent on both long-term internal (inside pond) and external (sources for pond supply and discharge waters) environmental and economic viability. Environmental viability is dependent on maintaining water quality at or above minimum standards for producing fish within the pond environment and for discharging pond water into the external environment. In turn, maintenance of water quality standards is dependent on the collective amount of wastes accumulated in the water resulting from the quantity and quality of feed nutrients used to culture the fish. These principles are the same for all pond production systems and are not unique in any way to 80:20 technology.

Feeds used to culture fish inevitably enrich pond water with metabolized waste. Table IX-1 compares the amounts of fish and wastes produced from feed at FCRs of 1.5 and 3.0. An FCR of 1.5 means that one unit of live fish is produced for each 1.5 units of feed, but this calculation is made without adjusting for dry weight of feed to produce wet weight of fish. The table shows that on a dry weight feed to dry weight fish basis an FCR of 1.5 is actually 6.75, or 6.75 units of dry feed to produce 1.00 unit of dry fish. It also means that 5.75 units of the feed went into the water as waste and pollution. Note that at an FCR of 3.0 the amount of feed is 100% greater than at an FCR of 1.5, but the amount of waste is 117% greater.

Table IX-1. Comparison of fish weight gain and wastes produced from feeds at FCRs of 1.5 and 3.0 (live weight of fish is approximately 80% water and 20% dry matter; pelleted feed is approximately 10% water and 90% dry matter).

Fish	Feed	FCR	
		1.5	3.0
100 kg live fish (20 kg dry matter)	Weight of feed pellets (kg)	= 150	300
	Weight of water in feed (kg)	= 15	30
	Dry weight of feed (kg)	= 135	270
	Dry feed to fish (kg)	= 20	20
	Dry feed : dry fish ratio	= 6.75	13.50
		= 1.00	2.00
	Waste in environment (kg)	= 115	250
	Waste : fish ratio	= 5.75	12.50
		= 1.00	2.17

The enriching-polluting substances resulting from pond fish culture are primarily the phosphorous and nitrogen contained in the feed. The fish (i.e. species, numbers and weights) are relatively incidental to the environment except as they relate to the amount of feed used to produce them. The quantities of phosphorus and nitrogen in fish feeds vary somewhat with feed quality, but are usually about 12 kg and 55 kg/t of pelleted feed, respectively (Table IX-2). Fish will assimilate some of these nutrients (about 5 kg and 14 kg, respectively, at FCR = 2.0), leaving the remaining 7 kg of phosphorus (= 16 kg P₂O₅) and 41 kg of nitrogen (per ton of feed

fed) to enter the environment as metabolic wastes. These wastes enrich phytoplankton production, which stimulates increased biomass at all trophic levels. Phytoplankton biomass in fish ponds is usually proportional to the amount of phosphorus entering the environment. However, increases in total biomass result in comparable increases in respiration causing proportional declines in night-time DO levels and LODOS. Therefore, the threshold for the amount of fish production in ponds can be generally determined based on the amount of pelleted feed used per area per day and the level of water quality management to restrict LODOS.

Table IX-2. Useful information for assessing environmental impact (eutrophication) of P and N from metabolized feed wastes.

1. Fish dry weight = 20-25% of wet weight
2. Phosphorous (P) = 1.2% of feed (varies from about 0.8-2.2%)
= 12 kg/ton of feed
= 4.1 % of fish dry weight
3. At FCR = 2.0 (2.0 kg feed to produce 1.0 kg net wet weight gain of fish)
 - a. 1.0 ton feed produces 500 kg fish weweight = 125 kg fish dry weight
 - b. fish assimilate 5 kg P (125kg fish dry weight x4.1% P)
 - c. therefore, metabolic P waste = 7 kg(12 kg P/ton feed - 5 kg P assimilated)
 - d. 7 kg P x 2.29 (1.0 kg P = 2.29 kg P2O5)= 16 kg P2O5 waste/ton feed
4. At optimum fertilization in ponds, P2O5 = 2.8 kg/week; therefore, 1 ton feed results in enough P2O5 (16 kg) waste to optimally fertilize a 1-ha pond for about 6 weeks.
5. Nitrogen (N) = 5.5% of feed (varies from about 4.5% to 7.0%)
= 55 kg/ton
= 11.2% of fish dry weight
6. At above conditions, the 55 kg in 1-ton of feed;
 - a. is assimilated in fish at 14 kg (125 kg dry fish x 11.2% N)
 - b. is released as waste into the environment at 41 kg/ton (55 kg total N - 14 kg N in fish)
 - c. results in enough waste N to optimally fertilize a 1-ha pond at 2.8 kg N/week for approximately 15 weeks.

Production performance of pond-cultured fish is limited by metabolic waste accumulation. Some enrichment is essential to establish a manageable fishpond ecosystem - a phytoplankton-based metabolic waste disposal system that converts potentially harmful substances into oxygen, food and benign substances. In newly filled ponds without sufficient phytoplankton density (e.g. visibility ³ 75 cm), fertilizers may be used to accelerate phytoplankton growth even though feeds are being used. Continued additions of nutrients as feed or fertilizer increase phytoplankton density eventually to an undesirable level. A phytoplankton density visibility of about 30 cm into

pond water is a general reference threshold where the advantages and disadvantages of nutrient loading are balanced. Water quality problems increase exponentially as water visibility decreases below about 30 cm. The threshold is not an absolute parameter that can be predicted for any situation as, for example, a road bridge engineer could predict the load limit for a specific support structure. Ecological systems are too complex and dynamic for that degree of accuracy. Also, the threshold is variable based on limits one wants to set on change of the environment. Thresholds vary with several environmental factors such as water surface area, water depth, depth fluctuations, and quality, quantity and frequency of water input into the pond.

Three feeding levels are given in Table VI-16 based on "safe", or sustainable, feeding amounts relative to water quality management systems employed. For example, a standard maximum safe feeding amount for channel catfish in ponds without aeration is 30 kg feed/ha/day. This quantity of feed would result in a daily release of about 0.54 kg of P₂O₅ waste/ha/day into the environment, causing it to become eutrophic. A pond in this condition would be very rich in phytoplankton (water visibility index of about 30 cm), thermally and chemically stratified at about 120 cm, anaerobic in the hypolimnion, and DO supersaturated to about 130% in the epilimnion in the afternoon and critically unsaturated to about 25% with LODOS conditions at dawn. Such water discharged into open waters would tend to cause similar eutrophic conditions in the environment, which would have different anticipated short- and long-term impacts depending on waste quantity and concentration distribution in the environment. In the short term, native fish biomass would increase, but in the long-term native species diversity would likely decline, species balance would be altered and the physical, chemical and biological relationships of the ecosystem would be destabilized. Those changes would not be permanent if pond discharges were discontinued, because the original, or very similar, ecosystem would re-establish itself relatively soon after discharges were stopped. The above example is based on feeding 30 kg feed/ha/day, but recommended amounts of feeding in ponds using 80:20 technology go as high as 120 feed kg/ha/day, which means metabolic wastes in discharge waters would increase proportionately or greater with increased feed amounts, increasing environmental impact by ³ 400%.

The purpose of the service 20% species in an 80:20 pond production system is to indirectly utilize wastes of the primary 80% species thereby improving water quality and production performance of the primary group while expanding total production of marketable fish from the pond. For example, without a service species a farmer might produce 4,000 kg of fish/ha with 8,000 kg feed for an FCR of 2.0 but using 80:20 technology with a service species the farmer might obtain 4,000 kg of fed fish plus 1,000 kg of filtering fish/ha for an FCR of 1.6, a 25% increase in fish biomass with the same amount of feed of 20% decrease in FCR. The weight of primary species was produced directly from feed, while the weight of service species was produced directly from plankton, which resulted from feed wastes passed by the primary species. If a predaceous species had been used as a component of the 20% group to control unwanted wild fish, the weight of that group would have also been an indirect result of feed.