

Environment-friendly practices in the aquafarm

FEED RIGHT, AVOID ANTIBIOTICS, RECYCLE WATER,
USE SETTLING PONDS, PROVIDE BUFFER ZONES,
PRACTICE POLYCULTURE OR INTEGRATED FARMING

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Feed right

Feeds are sources of nutrients for fish but are also the major source of wastes. Factors connected to feed quality, diet formulation, feed production technology and feeding practices greatly influence total waste loading. Sustainability of aquaculture depends on culture practices and prudent use of feeds. Poor feeding management can bring about diseases, slow growth, low survival, high feed conversion, environmental degradation, and poor harvest.

It is therefore very important that proper feeding management should be strictly observed. Some scientists suggest the following with regards to feeding practices that would minimize wastes:

- **Do not overfeed.** The main environmental effect of feed to aquaculture is excessive loading of nitrogen (N) and phosphorus (P) to the effluent discharged and accumulation of these in the environments. Nutrient overloading results to eutrophication especially in inland waters which can be detrimental to stocks. Too little food affect growth and harvest size but overfeeding may also lead to digestive and metabolic inefficiency and waste due to unconsumed food.
- **Establish feeding frequency, rate and amount, size shape and texture of feeds.** Feeding frequency varies inversely with fish size and behavior. Small fish are fed frequently. This practice tapers down as the fish grows. It is important to know the feeding behavior of the fish because the feeding habits of small fish differ from

those of big fish. Fish are also fed at the same time and in any manner each day with feed sizes not too large or too small for the fish. Particle density must also be considered since some fish feed on the water surface and others at the bottom. Fish that nibble the food before it is eaten should be fed with water-stable sinking feeds to reduce waste and nutrient leaching.

- **Use nutritionally-improved semi-moist or dry feeds.** This practice according to Bergheim and Asgard (1996) would improve feed utilization and reduce pollution. The feed conversion ratio (FCR) and effluent loadings of nutrients will also be reduced. FCR greater than 1.0-1.2 indicates feed proportion is lost to metabolism. However, energy and nutrient retentions and losses would give a more reliable estimate of waste produced than FCR.
- **Use well-digestible feed with proper protein and energy ratio to reduce the quantity of N discharge.** High energy diet, better processing and feeding techniques and the use of low temperature dried fishmeal increases dietary N and P retention thereby reducing waste production. In short, it should contain all required nutrients in good balance.
- **Know the water temperature of the species being cultured.** All fish has a water temperature range in which the most rapid growth and best dietary efficiency can be obtained. Fish require

higher protein at high temperature than at low temperature. Generally, fish utilizes saturated fats less efficiently at low than at high temperature.

- **Reduce protein content of feeds.** Fishmeal should be partially replaced by other plant protein sources. A 60% replacement of fishmeal with soybean meal or animal by-products reduced the P discharge by approximately 50% without effect on growth rate and feed utilization (Bergheim and Asgard 1996). With intensification of existing practices in the tropics, particularly of omnivorous species, plant products can be incorporated with commercial feeds. Sustainability can be ensured if precautions to minimize P and N discharges are taken by suitable treatment of ingredients.
- **Feeding schemes would depend on the species.**

- **For shrimp** (modified extensive system), feeding is done two weeks to one month after stocking, or until the shrimp are about 2 g or when natural productivity of the pond is diminishing. According to AQD researchers, shrimp juveniles require (in % of dry diet) 40% protein, 20% carbohydrates, 8-12% lipid, vitamins, and minerals. This information is useful because it would reduce pressure on valuable feed resources, and help diminish environmental degradation.

- **For milkfish**, supplementary feed is given only when lablab is limiting. Periodic "dressing" of the pond with chicken manure until two or three weeks before harvest is recommended to maintain high plankton growth.

- **Feeding grouper and seabass** stocked at low densities (0.5-1 per m²) with trash fish to satiation is best done once in two days.

- **Mudcrab** fed commercial shrimp pellets (36% protein) at 2% biomass, or trash fish at 10% BW for five weeks was found to be effective.

There are actually several issues raised regarding feeding approaches. Tacon in 1996



With automatic demand feeders, feeds are released as fish demands, hence, wastage is minimized.

for example compared approaches to feeding in China and Japan. China's fish production is largely based on polyculture and integrated farming systems. Livestock and agricultural crops serve as source of nutrients for the cultured finfish as pond fertilizers or low-protein supplementary feeds. Japan with limited area, employs intensive monoculture systems and uses high-cost nutritionally complete diets or high nutrient trashfish or shellfish. Although both farming systems may be economically viable, they have their own share of advantages and disadvantages depending on one's perspective. The former is of course, more sustainable.

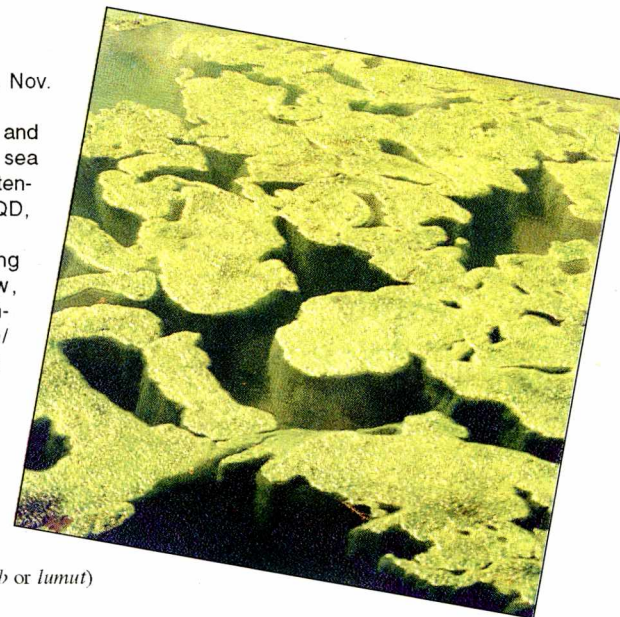
The following strategies are also recommended for removing the feed constraint in aquaculture: (a) selection of fish to suit available food resources; (b) polyculture technologies which balance natural food in the ecosystem with the feeding requirements of different species; and (c) improving the knowledge of locally available and on-farm feed resources.

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For milkfish and other omnivorous species, it is best to give artificial feeds only after the natural food in the pond (*lابلاب* or *lumut*) gets depleted.



Avoid antibiotics; probiotics are alternatives that need more tests

Microbial diseases have always been a serious problem in aquaculture. The collapse of the shrimp industry in the '80s was attributed to uncontrollable viral and bacterial diseases. The use of antibiotics did not solve the problem, instead, worsened it.

The indiscriminate use of antibiotics resulted to the development of resistant strain and contamination of non-pathogenic life forms around the culture system. These chemicals also bioaccumulate in the flesh of the farmed fish and can also damage biofilter in recirculating system.

Only 20-30% of antibiotics are actively taken by fish from medicated food which means approximately 70-80% is discharged in the environment (see also the April 1995 issue of AQD's *Aqua Farm News*).

The use of probiotics is an alternative measure to control microbial diseases and is gaining acceptance by aquaculturists.

Probiotics is defined by DE Jory, an aquaculture consultant in the US, as single or mixed cultures of selected strains of bacteria that are used in aquaculture systems (tank, pond and others) to modify or manipulate the microbial communities in water and sediment, reduce or eliminate selected pathogenic species of microorganisms, and generally improve growth and

survival of targeted species. In a way, probiotics is the opposite of antibiotics because it is a promoter of life, i.e., of beneficial microorganisms.

R&D on the use of probiotics for sustainable and environment-friendly aquaculture is accelerating. Application of probiotics in fish farming is not as developed and widespread compared with poultry, livestock and agricultural plant industries. Currently, their utilization in aquaculture is said to be in the early stages and consists of identifying suitable candidate strains and developing methods for their use.

Among the suggested modes of action of probiotics are:

- viable population of probiotics eliminates pathogenic bacteria after competition with food resources;
- they proliferate in the digestive tract thereby preventing the adhesion of harmful bacteria;
- the metabolites in the digestive tract thereby preventing the adhesion of harmful bacteria;
- they produce enzymes which aid in further digestion of feed in the alimentary tract; and
- probiotics stimulates the immunological system of the host species.



Although some of them are speculative there is no doubt that probiotics is effective and is an exciting new technology catching the attention of every aquaculturist.

To save the problematic shrimp industry several of the researches on probiotics are being focused on this area, especially in fry production. Below is a list of beneficial bacteria found to control *Vibrio harveyi* (main bacteria said to be responsible for the collapse of the shrimp industry) and improve survival of the shrimp *Penaeus monodon* and *P. penicillatus* larvae, and their special functions:

- *Bacillus* sp. - produces enzymes capable of dissolving proteins, lipids and carbohydrates
- *Pseudomonas* sp. - dissolves various solid organic substances in the sediment
- *Nitrosomonas* sp. and *Nitrobacteria* sp - converts toxic nitrogenous substances into non-toxic substances.

Right now it seems that the word probiotics is synonymous only to beneficial bacteria. With rapid advances in the development of highly reliable research equipment, it is foreseen that other species such as microalgae, fungi and viruses will also be in the spotlight. One thing to be remembered always though is probiotics should only be against targeted harmful species and they should never be pathogenic to humans.

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Schematics of a recirculating water system showing the three basic components: settling chambers, biofilter, and culture chambers. A pump is required to move water. Tertiary treatment and sterilization are sometimes added to such systems, along with other auxillary components (Stickney RS. 1995. p. 82)

Reuse and cycle water

Another technology of great importance for the future development of sustainable aquaculture is the recirculating aquaculture system (RAS). Believed to be the culture technique of the future, RAS is described as an intensive system where culture water is recycled and treated mechanically and biologically. In this way, release of waste water is controlled and monitored thus protecting the outside environment. To date RAS is used primarily in larval rearing.

RAS is usually located in areas with: (1) unsuitable site; (2) poor waste resources, (3) unsuitable climate; (4) lack of or insufficient control over production; and (5) environmental rules and regulations. These limiting factors are responsible for making RAS attractive among aquaculturists even though it requires high initial investment.

RAS is basically composed of three essential parts: one or more settling chambers, a biofilter and the culture chambers (see figure). Other components which have been added over the years vary considerably, but fundamentally they operate in the same manner.

- This is how RAS usually operates:
- Water from the culture chambers is discharged into the primary settling chamber where excess feed and feces are removed.
 - Water is then passed into the biofilter where bacteria detoxify ammonia (an-

other fish waste produce from the breakdown of proteins in the feed) and digest suspended organic matter.

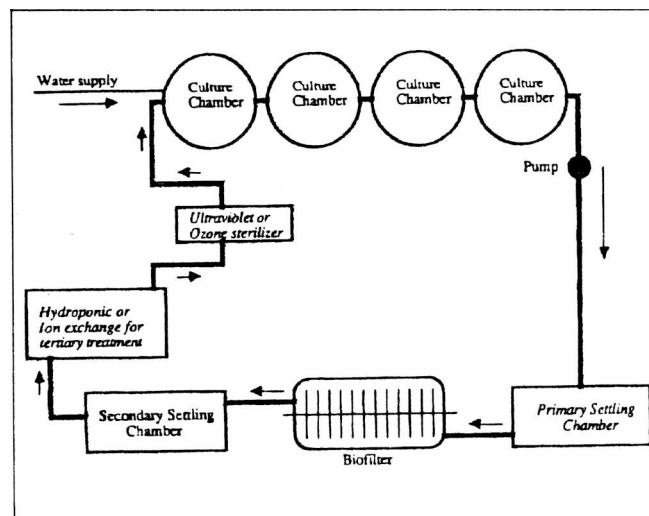
- The dead bacteria and remaining suspended particles are removed in the secondary settling chamber.
- Fish and bacteria produces CO₂ and bacteria produces nitrite and nitrate which are harmful to the cultured organisms. These chemicals are eliminated in the tertiary treatment chamber through air-water contact (stripping) and aeration, ion exchange or the growing of terrestrial plants (hydroponics).
- Before the water goes back to the culture chambers, it passes within one, two or all of these additional components: (a) temperature regulator, (b) oxygenation system and/or (c) ultra-violet radiation or sterilizer using ozone.

When constructing a recirculating system, make sure that: (1) materials used are non-toxic to the cultured fish, and (2) back-up motors and pumps are ready.

With increasing land prices, water shortages and strict government regulation on the effluents from aquaculture facilities, it is anticipated that more RAS will sprout in all parts of the world.

For a more detailed introduction on RAS components and their functions, readers are directed to:

- Remmerswaal RAM (compiler). 1995. **Recirculating Aquaculture Systems**. Infofish, Kuala Lumpur, Malaysia. 27p. (Infofish Technical Handbook 8)
- Stickney RR. 1995. **Principles of Aquaculture**. John Wiley & Sons, New York.



Use settling or sedimentation ponds

Aquaculture wastes such as nutrients and organic matter from uneaten feed and feces can cause rapid deterioration of water quality and pollution problems especially when ponds are drained and the pond water is discharged into surrounding waters.

This degraded or untreated water when re-used by neighboring farms will consequently result to disease problems.

A major pollutant in pond effluents is settleable solids. Avault (1996) recommended the use of settling ponds, among other solutions. A settling pond (chamber or tank) is an area where sedimentation takes place. In this pond, the exchange rate of water should be very low so that particulates or sediments can settle. The pond is designed on the basis of retention time. A settling basin with a retention time greater than 15 minutes was found to be sufficient for removing most of settleable solids.

Sedimentation is a process where suspended particles are separated from water by gravity. Stored water that is either undisturbed or has a slow flow rate allows sediments to settle and accumulate at the bottom. It requires little energy input, is relatively inexpensive to install and operate, requires no specialized operational skills and can be easily incorporated into both new and existing facilities.

Sedimentation may either be a principal wastewater treatment or a preliminary step for further wastewater processing. When used as a principal wastewater treatment, it removes (1) settleable solids capable of forming sludge deposits in the receiving waters, (2) free oil and grease and other floating materials and (3) a portion of the organic load discharged to the receiving waters. When used as a preliminary step for further wastewater processing - it reduces load on biological wastewater treatment. Primary sedimentation tanks can remove 50-70% of the suspended solids and from 25-40% of the biological oxygen demand which otherwise would be discharged directly to receiving waters.



AQD's new integrated broodstock-hatchery complex has facilities for wastewater treatment.

In the same way, when water from the river is to be used for the pond, a settling pond can be installed for sedimentation before the water is pumped into the pond.

The water in a settling pond is flowed in and out at the top so the material that has already settled does not become resuspended. A valve should be located at the bottom of the settling chamber to provide a means by which settled material can be removed periodically. Sloping the bottom of the chamber to the drain will make solids removal more complete and require less water removal from the system. In some designs, the primary settling chamber is ignored or is incorporated as part of the biofilter. In wide and deep raceways, these sediments can be removed near the drain end of the raceway with suction device. It is much easier done in shallow raceways where baffles are placed at intervals across and near the bottom of the raceway to accelerate water flow.

Solids removal with a primary settling chamber is important because it cuts down on the loading of the biofilter. The materials that are removed from the settling chamber are nutrient-rich and can be used as fertilizer.

Stetchey (1991) designed a settling basin with four zones to handle solids. (1) The inlet zone distributes influent across

the full width and depth of the basin to reduce the velocity of water flow. (2) The settling zone is the quiet, flowing part of the basin where solids settle out. These particles are affected by two main forces. Gravity results in particles dropping out, and at the same time the flow of water tends to push particles forward through the basin. (3) The sludge zone is where solids accumulate as the basin floor. (4) The outlet zone is where water is gently skimmed from the basin. In raceways, solids are settled out at its downstream end. The inlet for solids consists of a screen to keep fish from entering the settling zone.

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Provide mangrove buffer zone

Mangroves are the most important coastal ecosystem. Their immense diversity is very much known. They are important to aquaculture because they serve as nursery and feeding grounds as well as shelter to marine species during their juvenile stages of development. For aquaculture to survive, the industry should be compatible with the other users of the common resources and environment.

The unique features of mangroves complement aquaculture and fishery production. Adaptable to water stress, they allow the uptake of water against the gradient. The aerial roots absorb oxygen hence can withstand in areas where oxygen is limited. Mangroves act as a buffer zone against destructive wind and wave action. Other than being nurseries and buffer zones, the following functions of mangroves have been reported:

- Prawns and shrimp catch have been found to be directly proportional to mangrove area. The direct correlation between shrimp production and mangrove was studied and said to be 150% (Shiva and Karir, 1997).
- Primavera (1995) reported the variety of food that can be harvested from mangroves. With a little capital and labor-input, income can be increased by the introduction of rock mounds known as 'amatong' for fish aggregation, fish cage culture, crab fattening in cages, seaweed culture and mollusk culture on stakes, rafts and ropes. These technologies are applicable to small-scale, family level operations in mangrove-lined estuaries, bays and coves.
- Mangrove soils can act as sink for wastewater-borne pollutants. Tam and Wong (1995) assessed the capacity of mangrove soils to retain nutrients and heavy metals throughout a period of five months. The result indicated that mangrove soils are effective in removing P and heavy metals from wastewater of high strength. The degree of pollutant



removal, however, depends on the type of mangrove soils. Soil properties have different mechanisms to bind nutrients and heavy metals.

- Likewise, in the study of Wong et al. (1995), the ecological impacts of sewage discharge to a mangrove wetland was assessed by comparing with plant community, plant growth, and nutrient status of soils and vegetation of site treated with settled municipal wastewater with those of a control adjacent site which did not receive sewage. After one year, preliminary results showed that the discharge of a total volume of 2600 m³ municipal wastewater to an area of 1800 m² mangrove plants did not produce any apparent impact on growth of plants. The soil and plant leaves were not contaminated by the discharged waste. The mangrove ecosystem, said Wong et al. (1995) can purify the nutrients and inorganic matter from the wastewater.
- Robertson and Philipps (1995) studied the possibility of mangroves as filter of shrimp pond effluent. He estimated that between 2 and 22 ha of mangroves are required to filter nitrogen and phosphorus loads from effluent produced by a 1 ha pond. He stressed, however, that before mangroves can be used as filter,

more research is required on the effects of high ammonia and particulate organic matter loads in pond effluents on nutrient transformation in mangrove sediments and on forest growth. The correct balance between forest area and pond area has yet to be established in a regional scale.

- Binh and Philipps showed a study in Vietnam that a shrimp farm with 30-50% mangrove cover brings higher economic returns. Mangroves they said, also accelerate the formation of mudflats, expanding the delta towards the sea.

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Practice polyculture or integrated farming

Aquaculture is facing various environmental problems - pollution, scarcity of land and water resources, diseases, etc. This has brought about questions and doubts about its sustainability. Despite its negative impact, aquaculture is also being regarded as a means to improve food production. The conflict of aquaculture use would, therefore, depend on management and control of inputs in the system. There are sound management practices that are being recommended by scientists, the most common of which is integrating aquaculture with other aquatic species or agriculture crops and livestock. This is to optimize the use of land and water resources, the use of which is becoming the source of conflict. Aquaculture produces large amounts of wastes which degrade our environment. These wastes, however, can be a resource to other aquatic species.

• polyculture

Polyculture optimizes land and water use. It also does not require supplementary feeding, thus reducing the farmer's dependence on trashfish. Several reports suggest the economic viability and sustainability of polyculture.

Shellfish for example can grow abundantly in estuarine waters where aquaculture effluent is discharged. Seaweeds on the other hand, do not only add to the production yield but serve as biofilter of aquaculture effluents thus reducing risk of eutrophication in the environment (Troell et al. 1996). Seaweeds cultured with high-valued fishes has been reported to be viable and profitable. Polyculture of finfishes (milkfish-tilapia, sea bass-tilapia, milkfish-shrimp, etc) does not only improve production yields but minimizes use of resources. Reports of carnivorous seabass cultured with tilapia, grouper, snapper, shrimp and seaweeds were reported in October 1997 issue of *SEAFDEC Asian Aquaculture*.

Raising mudcrab in mangrove areas optimizes land use. Yield is improved and ecological balance is maintained. This is AQD's study site in Aklan.



• integrated farming

Both aquaculture and agriculture systems need sufficient amounts of water and access to land use. To optimize use of these resources, integrating aquaculture and agriculture is the ideal system because of its sustainability. In addition, in integrated farming wastes discharge from one system is a resource to the other. For example, manure from livestock can be used to fertilize ponds to grow lablab for aquaculture and also for agriculture crops. Using manure as fertilizer minimizes use of inorganic fertilizer that further degrades the environment. Leaves can also serve as food for fish like grass carp. This ultimately reduces production cost too.

Integrated farming has long been practiced hundreds of years ago. Rice-fish is the oldest and the most practiced integrated farming not only in the Philippines but also in Asia. This system, however, was overwhelmed by the intensive monoculture system in the 70's, especially shrimp farming because of short-term economic gains. Intensive aquaculture/agriculture was recently been regarded as the major cause of environmental deterioration. Inputs like feeds and chemicals have serious environmental effect. Because of this, scientists and government officials refocused thrusts and direction towards promotion of integrated farming

for sustainable development. Studies in Vietnam showed that a shrimp farm with 30-50% mangrove cover brings higher economic returns (Binh and Philips 1997). Rice fish research in 1984-87 in one of the provinces in Thailand indicated higher benefits than rice monoculture. A chicken-fish farming on the other hand, can yield 6,000 kg per ha per cropping with fish utilizing protein-rich processed chicken droppings. Same is true with duck-fish farming, fodder-fish, etc. SEAFDEC/AQD is verifying shrimp and mudcrab raised in mangroves and has been getting promising results so far. Several practical integrated farming practices applicable for small- and large-scale include rice-fish, rice-shrimp, fish-livestock, etc. More information may be found in the December 1997 issue of *SEAFDEC Asian Aquaculture*.

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