Farmers as Scientists

This is a series anchored by M.C. Nandeesha. It describes farmer-driven innovations and experiences.

Sewage Fed Aquaculture Systems of Kolkata A Century-old Innovation of Farmers

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Farmers around Kolkata city in India developed a technique of using domestic sewage for fish culture almost a century ago. This technique is widely used to meet the growing demand for fish in this thickly populated Indian city. The technique is considered to be unique and is the largest operational system in the world to convert waste in to consumable products.

The system appears to have started nearly a century ago although large-scale usage of sewage for fish culture began in the 1930s. Early success of fish culture in stabilized sewage ponds, which were used as a source of water for growing vegetables, provided stimulus for the large-scale expansion of sewage fed fish culture system. The area under this unique system of culture peaked at 12,000 ha, but in recent years there has been a steep decline in the area due to the increasing pressure from urbanization. Currently, the area under the sewage fed culture system has been reduced to less than 4,000 ha and the poor people dependent on these wetlands for their livelihood have been severely affected. However, even today, a considerable amount of fish consumed in Kolkata city is produced from this system. There are appeals to Government to declare the existing sewage fed aquaculture area as sanctuaries and to protect them from further encroachment by the rapidly expanding population of Kolkata city.

The waste recycling system that has evolved in Kolkata city involves garbage based vegetable farms, wastewater fed fishponds, paddy fields using fish pond effluent and sewage fed brackish water aquaculture. The practice of using pond effluent for paddy cultivation is of recent origin.

Sewage fed system

The sewage fed ponds, which are locally called "Bheries" are usually large and can be as big as 40 ha in size. Although these sewage-fed ponds are generally shallow and vary from 50 cm to 150 cm in depth. Though most of the sewage fed ponds are static in nature, with the increase in size, they tend to become lotic. In general, these ponds have five distinct phases covering pond preparation, primary fertilization, fish stocking, secondary fertilization and fish harvesting. Pond preparation is undertaken during cooler months (November-February) during which time the growth of carps is also reported to be slow. Whenever possible, ponds are drained, dried, silt is removed from the silt traps (perimeter canal dug along pond dike), the pond bottom is tilled and the dikes are prepared. Sewage from the canal is drawn in to the pond and allowed to stabilize for 15-20 days.

The photosynthetic activity in the pond is the basis for biological purification of the sewage. Once the water turns completely green, stocking

Sewage fed fishponds; locally called "Bheries" have a bamboo sluice structure to prevent the entry of wild fishes and escape of the stocked fishes.

Open channel through which sewage is flown. Lush growth of Colocasia seen on either side of the channel.

of fish is initiated. Before stocking fish, some are kept in hapas in the pond to test pond condition through survival. If the results are positive, large scale stocking is undertaken. Fish stocking takes place several times in a year depending on the intensity of operation.

Species cultured

Although both Indian and exotic carps are grown, farmers have specific preference for the Indian carps, namely catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and bata (*Labeo bata*) with bulk of the stocking consisting of mrigal. Exotic fish like silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) are stocked as a small percentage. However, the popularity of tilapias (*Oreochromis niloticus* and *O. mossambicus*) is increasing and they constitute 5-30% of the species stocked with different farms. There is also a tendency for some farmers to stock *Pangasius hypophthalmus* to control mollusc populations and some are attempting to culture high value species like giant freshwater prawn, *Macrobrachium rosenbergii*.

Periodic fertilization

After stocking, sewage is drawn regularly from the canal in small quantities. It is fed to ponds at doses varying from 1-10% of the total volume of water in the pond at intervals throughout the culture period. In bigger ponds, continuous inflow and outflow are maintained by allowing the same level of water to flow out of the pond. Water color, transparency, temperature and depth are used as measures to decide on the amount of sewage to be introduced in to the pond. Fishes are generally not fed with any supplementary feed, except on occasions such as the monsoon season when there is difficulty in getting enough good quality sewage.

Rotational cropping system

Farmers have evolved culture systems that are responsive to market demand. Fish are stocked and harvested throughout the culture period leading to periodical stocking and regular harvest. In larger ponds, harvesting takes place continuously for almost fifteen days in a month. After completion of one cycle of harvest in a large pond, fishes are restocked at the rate of one kg of fingerlings for every five kg of fish harvested. After restocking, fishes are left undisturbed for the subsequent fortnight and harvesting will start again after that period. Drag nets are commonly used for harvesting fishes through an encircling technique. However, for the bottom burrowing and difficult to catch species like common carp and tilapia, encircling with the net and hand picking are adopted as common techniques. There are specialized people to harvest fishes using these strategies.

The bulk of the harvested fish consists of Indian major carps and tilapia.

Sewage fed ponds are pumped out to dry.

Drying of ponds is undertaken during winter.

Silt is removed at least once in three years.

Dried water hyacinth is kept in heaps in the ponds for decomposition.

Dikes are some times used for the cultivation of horticultural crops like banana.

Specialists carry out harvesting of fish in large ponds. Tilapia and common carp are largely harvested through hand picking.

Live fish marketing

Large plastic containers are used in tricycles for the transportation of fish in live condition.

Live fish marketing is becoming more popular. Fish are harvested and kept in a depuration pond for varying lengths of time, but at least for one day. Depurated fish are harvested and transported to the market site live using containers placed on bicycles, tricycles and trucks. Based on the market demand, fishes weighing more than 100 g are generally harvested and sold. For example, if there are ten fishes in a kilogram, they are called hotel fish as they serve the needs of the restaurants that cater food to poor people. There are also skilled persons for the transportation of fishes in live condition for marketing using bicycles and they earn about Rs. 40-50 for 3-4 hours of work.

Aluminium vessels, called "hundies", are used to transport seed as well as live fish to market.

Dike protection

Aquatic weeds like water hyacinth are grown along pond dikes of larger ponds to break waves and prevent damage to dikes. In addition, these weeded areas, provide shelter to fish when the temperature rises, prevent poaching of fishes to some degree and most importantly serve as filters to extract nutrients and metals from the system. When these weeds grow in excess, they are periodically harvested and decomposed in the pond to enhance fertility of water. Surrounding these large ponds, silt traps 2-3 m wide and 30-40 cm deep are dug. These get filled with regular harvesting of fishes. Farmers restrict themselves to cleaning of these silt traps instead of digging the entire pond. Silt rich in nutrients is used for various purposes, including strengthening of dikes.

Disease problems

In sewage fed farms, bacterial diseases are not common. Even when there were problems with Epizootic Ulcerative Disease (EUS) in recent years with carps in other areas, carps in these sewage-fed ponds remained uninfected. However, parasitic infections by *Lernea* (anchor worm) and *Argulus* are common and there is a need to develop techniques for the control of this problem.

Ownership pattern of sewage fed ponds

Sewage fed ponds are operated both through individual operation as well as through cooperatives. Cooperatives have been largely successful in sewage-fed aquaculture systems and the poor are deriving good benefits from such systems. The practices adopted by some of the management systems visited by the author are presented here to highlight how the poor are deriving benefit from this system.

Jagrashisha Farm

This farm is 120 hectares in area. This large water area has been taken on lease from the owners by a group of three people for a period of twenty-one years and has more than 200 employees. One part of the farm complex consists of 58 ha comprising three large ponds with the largest pond having an area of 23 ha. The raw sewage drawn in to the pond is

Some sewage fed farms also integrate with pig farming.

conditioned for 20-30 days before stocking with carps and tilapia once the stabilization process is completed and water turns green. For every hectare of pond, about 40,000 – 50,000 fingerlings are stocked and the total weight of these fingerlings would be about one ton.

Most of the stocked material are major carps (70%) with other species including common carp, silver carp, grass carp and tilapia. Multiple stocking and multiple harvesting is the strategy adopted by this farm. Each pond is harvested continuously for fifteen days in a month. After harvesting one kg of seed is stocked for every five kg of fish harvested. Each farm maintains its own nursing area (about 10% of farm area is used for growing fingerlings) and stunted seed are stocked in to the pond continuously. While common carp and tilapia are produced on the farm, other species seed are obtained from local hatcheries. Fingerlings are generally more than 10-15 g in size when stocked. Fishes are grown mostly on the natural food produced in the pond and sewage is regularly drawn in at a rate of 2-3% of the total volume of pond water, using the color of water as an indicator. Aerators are used when oxygen depletion problems are noticed. Feeding of fish is generally not practiced, except when there is a heavy monsoon, resulting in shortfall of quality sewage. The market price of the harvested fish varies between Rs. 30-50 depending on variety and season.

The sewage fed system is threatened by the increasing urbanization. Note the multistoried commercial complexes behind the fishponds.

Employees are compensated adequately following the local systems and regulations with a weekly paid holiday, annual bonus and special holidays for festivals. Fish are harvested everyday by these laborers and depurated and transported by another group of hired contract workers who are paid Rs.40/ person for 2-3 hours of work. The farm also hires specialists to hand pick bottom dwelling fishes like common carp and tilapia and they receive at the rate of Rs. 3/- for every kg of fish harvested. Fish are harvested from all the ponds on rotational basis and on an average, there are 300 fishing days per year. The average fish productivity of the farm is more than five ton / ha / year.

Dr. Amitabh Ghosh and his team from CICFRI (Central Inland Capture Fisheries Research Institute) have been involved in carrying out research in partnership with the Bheri No.4 Cooperative.

Cooperative system of management

Bheri No. 4 is one of the cooperatives started in mid 1980s with the support of the government. The Society has 265 members with sixteen female members. The Society owns water area covering about 60 ha. A Management committee consisting of nineteen members manages the Society. Elections are held once in three years. The Secretary of the Society has been working in that position for the past ten years. This demonstrates the high level of confidence created by the leaders through their completely transparent system of management and provision of equal benefits to all members. Every member of the society takes part actively in the work and activities of the society and thereby conflicts are avoided. Each member receives a financial benefit of Rs. 2,000-2,500 /month along with a weekly paid holiday, annual festival bonus and special holidays. Members are also given limited medical reimbursement facilities. The annual transactions of the Society are large in magnitude with financial transactions amounting to more than Rs. 13 million. This is a huge sum in the local context and there is lot to learn from these successful cooperatives. The Society uses its own labor force for harvesting fishes and marketing them in live condition.

Several of the aquaculture management practices adopted by the Society are similar to those described earlier. The major expenditure of the farm is on procurement of seeds from hatcheries since the farm produces only common carp and tilapia seed on site. The Society has also set up a good integration system with pig farming and on an average 300 pigs are raised on a continuous basis. The Society has a number of assets like nets, boats and trucks, which are required for the efficient operation of the farm. Fish are harvested continuously almost everyday throughout the year, except for a month break in the whole year.

"Cooperatives have been largely successful in sewage-fed aquaculture systems and the poor are deriving good benefits..."

Conclusion

Integrated resource recovery systems and waste recycling using peripheral wetlands around cities are some of the planning concepts suggested to maintain the good environment around urban areas. Unfortunately, Kolkata wetlands, which served as the best examples to the world on these concepts are slowly being lost due to the urban expansion without understanding the ecological, environmental and economical benefits of this sewage fed fish culture system. While there is a necessity to protect this unique system in Kolkata, there is a much more urgent necessity to understand the science behind the management practices evolved by farmers. The quality of fish grown in sewage fed ponds remains as one of the major concerns, though the practice followed by farmers for nearly a century demonstrates the robustness of the system. Some of the studies conducted to understand the microbiological and chemical qualities of fish grown in sewage fed ponds indicate that the fish are safe to consume.

An international seminar held in 1988 in Kolkata city with the support of UNDP – World Bank Water and Sanitation Program, ESCAP and the Government of India, brought together experts and countries, which have some form of sewage fed systems. The seminar also recognised the uniqueness of the Kolkata system and recommended that detailed studies should be undertaken to understand the existing practices and also assesses the quality of fish. Dr. Peter Edwards from the Asian Institute of Technology and Dr. P.S.V. Pullin from ICLARM have edited and published the proceedings, which has wealth of information and a number of other recommendations. As it is clear, even within the country, even after a century of this important innovation, the technique has not spread to other parts of the country. What is preventing the adoption of this novel system – is it social, economic or technical constraints or are a combination of all these?

"There is opportunity...to produce fish...and avoid environmental damage being caused by the discharge of untreated sewerage."

Perhaps bringing farmers living around urban areas and "doers" from the scientific and development community to see this practice of Kolkata might help in applying the system elsewhere in the country with suitable modifications. The Public Health Engineering Department has to be impressed with the potential of this system and the Fisheries Department has to work closely with them to develop new systems in other urban areas. The Central Institute of freshwater Aquaculture located in Bhubaneswar has reported the development of an improved method of sewage fed fish culture system, which avoids the direct use of raw sewage in fish culture. Though there are fears about the safety of the fish grown in sewage fed systems, it is the general belief in Kolkata that the fish grown in sewage tastes better. This has been partly attributed to the good nutrition obtained from the rich plankton growth in ponds. Plankton for the growing fish.

There is opportunity to develop systems suitable to each of the urban centers to produce fish using sewage and avoid environmental damage being caused by the discharge of untreated sewage.

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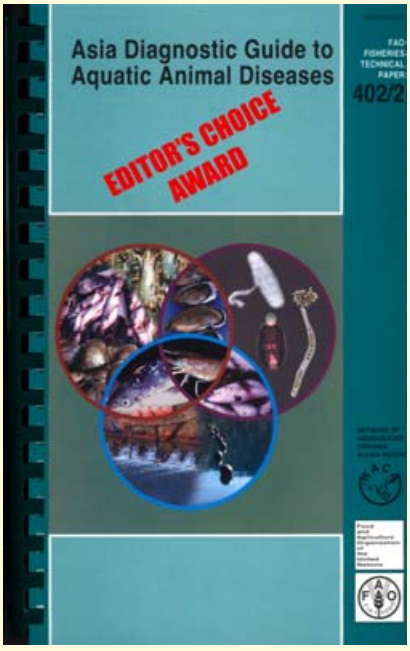

Asia Diagnostic Guide to Aquatic Animal Diseases

The Asia Diagnostic Guide is a comprehensive, up-datable diagnostic guide for the pathogens and diseases listed in the NACA/FAO and OIE Quarterly Aquatic Animal Disease (QAAD) Reporting System including a number of other diseases which are significant in the Asia region. It jointly published by FAO and NACA under the Asia-Pacific Regional Programme on Aquatic Health Management.

This 240 page volume contains a general introduction on health and aquatic animals and the roles and levels of diagnostics. Section 2 to 4 cover Finfish Diseases, Molluscan Diseases and Crustacean Diseases. Each host section commences with a chapter on "General techniques" which covers essential starting points that will enable prompt and effective response(s) to disease situations in aquatic animal production. These chapters are not disease specific and emphasize the importance of gross observations and how and when they should be made, including information on environmental parameters worth recording, general procedures for sampling and fixation and the importance of record-keeping. The guide is illustrated with more than 160 colour photos. Limited hard copies and a CD version are available for cost of postage. A free electronic (PDF) version is available from the NACA website (http://www.enaca.org/aapqis/ - visit the publications link).