Peter Edwards writes on

Rural Aquaculture

An increasingly secure future for wastewater-fed aquaculture in Kolkata, India?

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A previous column 'Peri-urban aquaculture in Kolkata' (Aquaculture Asia, Volume VIII, Number 2, pages 4-6, 2003), was based on my involvement in the UK Department for International Development funded project 'Land-water Interface Production Systems in Peri-urban Kolkata'. The project addressed issues threatening the livelihoods of poor people who depended on wastewater-fed aquaculture for employment and/or as a source of relatively cheap fish.

It was pointed out that even though the fish ponds were recognised as a low-cost sewage treatment system for the city of Kolkata, the single largest threat to the system was filling in the ponds for urban and industrial development. The so-called East Kolkata Wetlands occupied by the wastewater-fed fish ponds were plagued with poor governance as an intersectoral planning and management body did not exist. Insecure tenure of the fish ponds had led to little desilting of the ponds for decades leading to shallow water that limited fish production. However, there was hope for improvements as the

A secondary sewage feeder canal in the foreground - nursing ponds in the middle ground and a large grow-out pond in the background.

A pond drainage outlet.

development of a new city to the north of the East Kolkata Wetlands had created a market demand for silt as landfill; and the East Kolkata Wetlands had been designated as a Ramsar 'Wetland of International Importance' in 2002 on the basis of wise use to produce a range of goods and services, especially a low-cost, efficient and eco-friendly system of sewage treatment and a habitat for diverse flora and fauna including waterfowl.

Five years later I was back earlier this year to assist Dr Stuart Bunting of the University of Essex, UK with an Asia Development Bank (ADB) funded project on 'Capacity building for the East Kolkata Wetlands'. We assisted the recently established East Kolkata Wetlands Management Authority (EKWMA) to prepare sections of an Environmental Management Plan for the East Kolkata Wetlands.

Overview

There are 254 wastewater-fed fisheries occupying an area of about 3,800 ha, the largest wastewater-fed system in the world, treating the city sewage and producing an average yield of 4 tonnes/ha of carps and tilapia. Details on the functioning of the system were provided by Dr Nandeesha in his article 'Sewage-fed aquaculture systems in Kolkata, a century-old innovation of farmers (Aquaculture Asia Volume V11, Number 2, pages 28-32, 2002).

Passing the 'The East Kolkata Wetlands (Conservation and Management) Act, 2006' represented a major constitutional commitment to preserving the wetlands for current and future generations. The Act presents a schedule of landholdings within the East Kolkata Wetlands, specifying their character and mode of use; and sets out the functions and powers of the EKWMA. A preliminary task of the EKWMA has been to develop the four sections of the environmental management plan in consultation with stakeholders, ie: Aquaculture Management Plan; Wastewater Management Plan; Waste Recycling Plan; and Best Practices Plan. We also prepared an Environmental Management Manual to support implementation of the East Kolkata Wetlands EMP with a summary of the main production systems in the East Kolkata Wetlands, highlighting constraints threatening specific production sectors and wise-use of the wetlands generally, and outlining Best Practices that should be promoted amongst wetland managers, user groups and other stakeholders to help safeguard and enhance the wetlands. Specific guidance in the manual includes Best Practices relating to upgrading and maintaining the canal system and fishponds; implementing the WHO guidelines for safe wastewater use; and prospects for enhanced aquaculture production.

Sustainable canal and fish pond rehabilitation, operation and maintenance

Two major constraints to more effective treatment and reuse of wastewater in the East Kolkata Wetlands fish ponds are insufficient wastewater entering the fish ponds; and reduced pond depth due to siltation. These are currently being addressed through various initiatives in various stages of implementation.

Wastewater from the inner city of Kolkata with about 4.5 million people, an average daily flow of wastewater of 1.1 million m^3, is not treated by a conventional sewage treatment plant but an estimated 30-50% of the sewage is treated by the maturation/ fish ponds of the East Kolkata Wetlands. Sewage mainly enters the fish ponds during 270-300 days of the year as the regulator gate at Bantala on the main sewage canals leading from the city is kept closed during the dry season to raise the level of wastewater in the canals so it flows into fish pond feeder canals and then into the ponds. However, the regulator gate is kept open during the monsoon season to lower the water level in the main canals to prevent flooding in the city. Thus, during the monsoon season the level of the fish pond feeder canals is usually too low to permit wastewater to enter the fish ponds by gravity. Farmers complain of inadequate wastewater to feed their ponds, especially in the rainy season. Increased wastewater flow would also allow up to 1,000 ha of former fish ponds currently being used to grow rice to be converted back to more economically attractive wastewater-fed fish culture. Several hundred hectares have already been reconverted to fish ponds from rice paddies over the last few years.

The overall aims of the current ADB-funded Kolkata Environmental Improvement Project (KEIP) of the Kolkata Municipal Corporation (KMC) are to provide better flood control of Kolkata and to improve environmental protection. A specific aim is to improve wastewater handling in the East Kolkata Wetlands to provide stronger wastewater to feed the fish ponds. KEIP is to separate currently mixed dry weather flow and storm weather flow at the main city pumping stations. It is proposed to construct a siphon just upstream of Bantala so that the entire dry weather flow throughout the year will be channeled into the fish ponds. The present fish pond intake at Bantala is to be abandoned so that the regulator gate can then be used solely for flood control, thereby resolving the conflict with fisheries. The main dry weather flow channels between the city and the fisheries are also being desilted. Two existing semi-derelict siphons on the main dry weather flow canal that feed fish ponds in the southern East Kolkata Wetlands area will also be upgraded to increase sewage flow.

The construction of sewerage and drainage networks by KEIP in areas outside the inner city will result in increased quantities of sewage. KEIP initially intended to construct two new sewerage treatment ponds to serve the new sewage and drainage networks but it is unlikely that these will be built as a recently completed study by Jadavapur University has concluded that the East Kolkata Wetlands can absorb the additional quantities of sewage from the outer city areas, only an estimated 13-14 %. KMC has decided to allocate KEIP funds from financial savings in the construction and operation

The regulator gates at Bantala which control the level of wastewater in the main canal.

The fish feeder channel at Bantala.

A satellite map of the East Kolkata Wetlands pond system.

of the sewerage treatment ponds to improve the supply and distribution of wastewater for the East Kolkata Wetlands fish ponds.

A project managed and coordinated by the Department of Housing, Government of West Bengal (WBHIDCO, 2004) has been implemented to deepen the fish ponds with the excavated silt used for land fill for an urban development to the north of the East Kolkata Wetlands, New Town or Rajahat.

We also recommended that KMC consider introducing a sewage tax derived from the central city to be used to maintain the main wastewater feeder canals to the fish ponds as the East Kolkata Wetlands provides an ecological service to the city by treating its wastewater. This saves an estimated total investment of US$ 125 million, excluding annual operation and maintenance cost, to treat the sewage from the inner city by conventional mechanical secondary sewage treatment.

Safe use of wastewater in aquaculture

The World Health Organization (WHO) has recently published revised guidelines for the safe use of wastewater in aquaculture. WHO recognizes that the use of wastes in aquaculture can help communities to grow more food, increasing household food security and improving nutrition for poor households in farming communities and urban areas and make use of precious water and nutrient resources, helping to achieve the United Nations Millennium Development Goals 1: Eliminate extreme poverty and hunger, and 7: Ensure environmental sustainability.

WHO recommends that practices and targets should be based on local social, cultural, environmental and economic conditions and be progressively implemented over time depending on current reality and existing resources, leading to continual improvement of public health. This is because introducing overly strict standards may not be sustainable and, paradoxically, may lead to reduced health protection because they may be viewed as unachievable and thus be ignored.

Health hazards

Various hazards are associated with waste-fed aquaculture: excreta-related pathogens (bacteria, helminths, protozoans and viruses), skin irritants, vector-borne pathogens and toxic chemicals. Fish passively accumulate microbial contaminants on their surfaces but they rarely penetrate into edible fish flesh or muscle except trematodes. The relative risk of disease from bacteria e.g. *Salmonella*, Protozoa e.g. *Giardia*, and viruses e.g. hepatitis, is low to medium although there are always high concentrations of microbes in the gut of fish. The major health hazard associated with wastewater-fed aquaculture is from food borne trematode worms (intestinal, liver and lung flukes) and schistosomes (blood flukes). Fortunately, their restricted geographical range excludes India. The risk from vector-borne pathogens e.g. malaria, is nil to medium, with no specific risk associated with aquaculture as mosquito larvae are readily consumed by fish.

Dredging the main sewage canal above above Bantala.

Manual desilting of a fish pond.

A large farm-level sewage pump.

Regarding the risks from chemicals, that from antibiotics is nil to low as they are not usually used in wastewater-fed aquaculture. The risk from heavy metals is low as most are likely to be removed by settling in the anaerobic wastewater canals supplying the fish ponds and by precipitation in the alkaline water of the fish ponds. Although they may accumulate in fish, concentrations of heavy metals from fish raised in wastewater-fed aquaculture do not usually exceed levels recommended by the Codex Alimentarius Commission. The

Pumped sewage distributed on a farm.

Small fish ponds converted from rice fields with a sewage feeder canal in the foreground.

Harvesting fingerlings from a nursery pond.

Final harvesting of fish by seining a large pond. Note the shallowness of the water.

A harvest of small carp.

A harvest of small Nile tilapia.

Government of West Bengal is making steps to prevent the discharge of industrial wastes into municipal wastewater and is relocating polluting tanneries from the city. The risk from halogenated hydrocarbons is low as they are generally in low concentrations in wastewater and fish raised in wastewater usually show only low concentrations.

Transporting fish to market on foot and by bicycle.

Arrival of fish at a wholesale market.

Purchased fish being kept alive by manual agitation of water in containers on a truck at a wholesale market.

Health protection measures

A variety of health protection measures can be used to reduce health risks to fish consumers, workers and their families, and local communities. It is recommended that reduction in the risk of exposure to pathogens be achieved by a combination of interventions or barriers i.e. constructing "multiple barriers" to prevent exposures to pathogens and toxic chemicals.

There is rapid die-off of pathogens in wastewater-fed "green water" ponds due to intense phytoplankton photosynthesis and high pH which is lethal to enteric pathogens so it is recommended that wastewater flow into fish ponds be suspended before harvesting fish to allow for die-off.

Aquacultural workers should limit their exposure to wastewater, in either the feeder canals or in ponds in which wastewater is being introduced. They should rinse their skin thoroughly with clean water after contact with wastewater or pond water contaminated with wastewater. Aquacultural workers as well as local communities should be provided with access to safe drinking water and adequate sanitation facilities. They should practice good personal hygiene, especially thoroughly hand-washing with soap and water prior to food preparation and eating, after defecation and after cleaning a baby's faeces.

Market hygiene should be improved by provision of clean water to transport fish and to handle fish at the market, as well as provision of adequate sanitation facilities at markets. Although pathogens rarely occur in fish muscle they may occur in fish intestines so prevention of cross-contamination with other food in the kitchen is essential when fish are being prepared for cooking. Cross-contamination of foods in the kitchen is the greatest risk which is reduced by hygienic processing and cooking.

The risk from infectious diseases from wastewater raised fish is also significantly reduced if the fish are thoroughly cooked before being eaten as with Bengali cuisine.

Towards enhanced fish production and profitability

Fish production and profitability of the East Kolkata Wetlands ponds are relatively low for semi-intensive fish culture compared to Andhra Pradesh (see my column in Aquaculture Asia, Volume 13, Number 3, Pages 3-7, 2008). Some East Kolkata Wetlands farms attain annual yields of 5-7 tonnes/ha but mostly farms produce 3-5 tonnes/ha, only one third to one half of sustainable production from well managed semi-intensive fish culture.

The major species currently farmed in the East Kolkata Wetlands (carps and Nile tilapia) are appropriate species for semi-intensive fish culture but improved strains would considerably increase production. Production of rohu could be increased by stocking an improved strain of rohu that has been developed by a Norwegian funded project through the Central Institute of Freshwater Aquaculture and tilapia production could be increased considerably by importing improved strains of Nile tilapia from Thailand. Production of large-sized tilapia is facilitated by use of mono-sex culture which should be explored alongside the introduction of improved strains.

As farming tilapia is still officially banned in India, permission would need to be sought to import new strains even though the species is a major component of production in the East Kolkata Wetlands.

Fish culture in much of the East Kolkata Wetlands is currently constrained by shallow ponds and inadequate distribution of wastewater although these are being rectified as discussed above. The widespread use of farm-level pumps to fill ponds with wastewater should eventually be unnecessary and this would increase profitability.

Supplementary feed is required to maximize the profitability of semi-intensive fish culture. This is best used later in the growth cycle to enable the fish to continue to maintain a rapid growth rate when they exceed about 100 g individual weight. Natural food alone is insufficient for larger sized fish to continue to grow and increase in weight. Although supplementary feed is used in the monsoon season to compensate for inadequate wastewater, its effective use is constrained by large pond size and harvest of relatively small-sized fish. The latter is a consequence of labour unions demanding excessive seining of ponds; although it leads to the production of relatively small and cheap fish affordable to the poor, it reduces the potential production and profitability of aquaculture in the East Kolkata Wetlands. The production of higher yields of large-sized fish in at least some ponds would improve the economic efficiency of fish production and at the same time lead to greater economic development and provision of jobs for poor workers. This should be explored through tripartite negotiation between fish producers, farm worker unions and government agencies. A three-stage system of nursing, rearing and grow-out ponds is utilized by some farms but, as discussed above, the most profitable way to farm fish is to stock large fingerlings of 100-200 g (the current size of final harvest) and harvest them only after their growth declines as larger fish fetch 2-3 times higher a price in local markets than small-sized fish.

First culture-based fisheries growth cycle in Lao PDR is overwhelmingly encouraging

Sena De Silva, NACA Director General

The first growth cycle trials for the project *Culture-based fisheries development in Lao PDR* were completed in May-June 2008. Although the rains occurred earlier than normal and restricted harvesting, the results obtained even with a partial harvest are extremely encouraging. All indications are that culture-based fisheries activities (CBF) are going to be adopted by many communities, including by some neighbouring villages acting on their own, and will contribute significantly to their nutritional, financial and social well being in the years ahead.

The objective of this ACIAR-funded project is to develop applied production models to optimize yields from culture-based fisheries in flood plain depressions and reservoir coves, thereby improving food fish availability and income generation. The project is being undertaken in eleven villages in two provinces of Lao PDR.

Community engagement in harvesting, Thong Van Village.

All fishery communities participating in the project - formed from farming communities with access to water bodies - gained significantly, not only in financial terms but also in the way of community development and well being. Individual communities have met at least once or twice a month and made collective decisions with regard to maintaining stocks, harvesting procedures and dates. They have also agreed on marketing strategies that include fixing a minimum saleable price for individual species of fish, and most important of all, the manner in which the profits are to be shared.

All communities without exception made substantial profits from the first year of activity, and deposited sufficient funds, ranging from 3.5 to 6.5 million kip (US$1 = 8,700 kip) to purchase fingerlings for the next stocking. The manner in which the rest of the profits were disbursed varies between communities. For example, all households engaged in the fishery activities were allocated a sum ranging from 3.5 to 6.0 million kip, depending on the returns, and in some communities those engaged in the activities were also paid a daily wage for their inputs, such as for guarding the stock. The entire village, including those households that were not actively engaged in fishery activities, was allocated 2 to 4 kg of fish per household for consumption, and fish were also contributed to social functions.

In some communities the proceeds from the harvests, after depositing funds for the purchase of new seed stock, were used entirely for community activities. For example, in the Thong Van Village (Paksan District, Borikhamxay Province) the funds were used to upgrade the village temple, and this community plans to use its future profits to upgrade the village school and so on. In other communities, in addition to