Demise of Periurban Wastewater-fed Aquaculture?

Recent field visits of the author to periurban areas in Bangladesh and Vietnam indicate that some wastewater-fed aquaculture systems may have limited prospects, while others prove difficult to extend. The major constraining factor is the limited availability of land in rapidly expanding cities.

Wastewater-fed aquaculture occurs in several countries in East, South and Southeast Asia, where it provides food, employment and income for millions of people, especially the poor. Furthermore, it provides a low-cost method to treat wastewater as well as a means to reuse both nutrients and water. The recent Hyderabad Declaration on Wastewater Use in Agriculture recommended a holistic approach to the management of wastewater in aquaculture as well as agriculture through treatment and reuse schemes to alleviate poverty in urban areas. A range of sound wastewater reuse practices in aquaculture has recently been outlined (Edwards 2002).

The reality is that very few new systems of wastewater reuse in aquaculture have been implemented; and traditional systems are threatened or in decline (Edwards 2000). Recently, as a consultant for the DFID-funded project "Capacity-building for effective decentralised wastewater management" being carried out by the UK company GHK International with partner institutions in Hanoi, Vietnam, and Khulna, Bangladesh, I witnessed the latest developments in, or what may very well be the demise of, wastewater-fed aquaculture in periurban areas of fish and duckweed/fish.

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HANOI

Wastewater in Hanoi is discharged without treatment into a network of rivers that flows to the south of the city through Thanh Tri district, and eventually into the Red River (although plans are underway to install conventional mechanical wastewater treatment plants). Based on experience accumulated over the past four decades, farmers have developed wastewater-fed aquaculture involving either a polyculture of finfish with or without rotation with rice, or aquatic vegetables (see also page 9-11)). A large number of individuals, especially people of lower socio-economic status, are involved in production and marketing of wastewater-fed produce, either part or full-time. Produce is also consumed by a large number of people, especially the poor. While men are especially involved in fish culture and in the transportation and wholesale marketing of fish, women predominate in the farming and transportation (on bicycles and motorcycles) of aquatic vegetables. Women also dominate in the selling and buying of produce in retail markets.

The author first visited wastewater-fed aquaculture in Thanh Tri district in 1991 but I was amazed recently by the current rate of change, with the rural landscape of fields and ponds rapidly being converted into one of brick and concrete. Under the first phase of the Hanoi Master Plan for sewerage, drainage and environmental improvement, wide drainage canals, storage reservoirs and a pumping station have been installed in areas recently occupied by wastewater-fed fish ponds. Buildings are sprouting like mushrooms all over the district, right up to the water's edge of fish ponds. Large blocks of buildings co-exist with the remaining fields. In interviews, women aquatic vegetable farmers expressed, without exception, fear that urbanisation will soon encroach onto their fields, resulting in the loss of their livelihood.
The old Thanh Tri district was recently divided in two. The northern half in

Encroachment of housing on wastewater-fed fish ponds in Hanoi, Vietnam.

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which most wastewater reuse takes place, was renamed as a new district, Hoang Mai, and declared an urban area in November 2003. The Chairman of the People's Committee of Yen So Commune, one of the major wastewater-fed aquaculture areas, confirmed that the fish pond area had declined over the last 10 years due to use of land for construction.

While the map for 2001 in the Hanoi city Master Plan indicates large areas of fish ponds, as observed during my recent visit, none were indicated for Hoang Mai district for 2020. Most of the Hanoi government support for aquaculture is planned for high-value aquaculture species such as red tilapia, river catfish and giant freshwater prawn. The emphasis will be on new technologies in aquaculture, with incremental development expected to be in line with industrialisation and modernisation. The trend is to convert wastewater-fed fish culture into organic and intensive fish culture. The fish species component is to change, with priority being given to high-quality seed of high-value aquaculture species.

The area devoted to growing wastewater-fed terrestrial vegetables has declined even more than that of ponds and aquatic plant fields in Hoang Mai. This is because the higher and drier land formerly used to cultivate terrestrial vegetables was more likely to be built on first, before the lower water-logged land used for aquatic vegetables and fish culture. Furthermore, Hanoi has a programme to promote "safe vegetables" in three other districts of the city. Although it is recognised that use of night soil, septic tank sludge and wastewater as fertilisers on vegetables is still widespread, this practice is not recommended. Guidelines for safe vegetables specify better management of pesticides and no night soil or wastewater, although use of composted livestock manure is allowed.

Although the rapid change of land use to urban development with an associated marked increase in land value is the main factor in the on-going demise of wastewater-fed aquaculture and agriculture in Hoang Mai district, there are other factors involved. The increasing content of industrial effluents in the total wastewater stream has a significant adverse effect on both fish growth and survival. Farmers reported that fish ponds could only safely accommodate 10-30% wastewater by volume, much lower than previously, due to suspected toxic chemicals. The Chairman of the People's Committee of Yen So commune told me that farmers recently lost 2 tonnes of fish in the pond adjacent to his office because of mass mortality due to poisonous wastewater. Farmers now have to supplement low volumes of wastewater with other fertilisers such as livestock manure, although little is available, and readily available beer and wine residues as feed. As the price of pelleted feed is high, farmers lose money if they use it to raise relatively low-value wastewater-fed fish.

Furthermore, the quality of fish raised on wastewater is said to be poor, with a bad smell and taste, because of industrial chemical effluents now present in the previously mainly domestic wastewater. As most fish raised in wastewater-fed ponds are also small, they are difficult to market in the increasingly sophisticated Hanoi markets, where there is demand for large fish. Wastewater-fed fish supplied as much as 40% of Hanoi's daily requirement for freshwater fish in the past, but now they are mainly marketed in remote rural areas in central and north Vietnam, and mainly for poor people. In contrast, most wastewater-fed aquatic vegetables are marketed in Hanoi although most consumers are unaware of their origin.

KHULNA

It is a traditional Chinese practice to cultivate duckweed, using various organic fertilisers, in order to produce small green fodder for grass carp fingerlings still not large enough to consume coarse grass. A tremendous amount of research has been conducted over the last three decades on various aspects of duckweed, including its cultivation on wastewater and subsequent use to feed herbivorous fish (IHE/PRISM 1999, Iqbal 1999).

Duckweed has many positive characteristics, like high crude protein production (10 times greater than that of soybean); a high crude protein content; the ability to grow in shallow water and shade readily harvested by pole and net. Unfortunately there are also constraints involved in its production: its growth is adversely affected by both low and high temperatures, and high light intensity; occasional insect infestation; and rapid decomposition following harvest.

The NGO PRISM in Bangladesh has carried out an R&D programme focused on duckweed-based wastewater treatment and reuse through fish culture over the past 15 years. Two systems have been developed: a system fed with conventional wastewater or sewage for periurban areas; and a village-level sanitation system in which latrines are connected to small derelict ponds to treat night soil and cultivate duckweed.

The first duckweed-based conventional wastewater treatment system, which still operates, was built in 1989 at Mirzapur, Tangail district. A 0.2 ha anaerobic pond precedes the 0.7 ha duckweed-covered pond, which is constructed as a 500 m long serpentine channel with a hydraulic retention time of about 20 days. About 1,000 m^3 sewage / day are treated to such a high degree that the effluent could be used for unrestricted irrigation of vegetables according to WHO standards for wastewater reuse. Duckweed harvested daily is fed to fish in three adjacent fish ponds of 0.2 ha each. About 10-15 tonnes of fish, mainly carp, are produced each year, although probably only half the yield is based on duckweed as rice bran and oil cake are also fed to the fish. The net return is 5-10% annually, including leasing of the land and 5-year facility depreciation (Mohammed Ikramullah, Chairman of PRISM personally comment). PRISM has demonstrated that it is possible for a duckweed-based wastewater treatment system incorporating fish culture to not only achieve cost recovery but to derive a net profit.

Despite the demonstrated economic feasibility of low-cost, duckweed-based wastewater treatment and reuse, PRISM has major reservations about further dissemination of the technology in Bangladesh. The local government in Khulna, the third largest city in Bangladesh, provided 0.6 ha of land for a duckweed-based system at Sonagandha. The community-based project involving active participation of an adjacent slum community was funded by UNCDF but was destroyed only 3 years later to build a stadium for female athletes, as no other land was readily available. UNDP provided funds to build four duckweed pilot plants in Khulna, but sufficient land could be found to build only two plants. Plants built on leased land on the campus of the Agriculture Training Institute in 2000 and at Shobujbagh on private land bought by PRISM in 2003 are currently in operation. However, it is unlikely that land will become available to build additional duckweed-based plants either in Khulna, or elsewhere in Bangladesh.

The single biggest constraint to the sustainability of duckweed-based wastewater treatment and reuse is the availability of land for what is essentially a land-intensive system. The PRISM concept for duckweed was based on use of marginal and unutilised, fallow land. Earlier studies had reported that there were 250,000 ha of low-lying land in Bangladesh which could be used for natural collection, treatment and reuse of wastewater. However, the opportunity cost of land has gone up rapidly in Bangladesh, the most densely populated country in the world, excluding city states. In reality there is no shortage of land as plenty is held, especially by five bodies: municipalities, Post and Telegraph, Railways, Roads and Highways, and Water and Power Development Board. As the opportunity cost of karst (government) land has risen so much, there is pressure to use the land for various purposes, legal and illegal. Land speculation is the biggest business in Bangladesh. Although land availability is the biggest issue, other major constraints are also complex, including multiple ownership of land, limited availability of working capital, and the rapid rate of infrastructure development, which often results in water bodies being filled in. Duckweed wastewater treatment does not seem to be attractive enough to gain full government support.

PROSPECTS

Wastewater-fed aquaculture appears to be a transient phenomenon of pre-industrial and early industrial societies in which reuse of wastewater is socially acceptable because of high population pressure and scarce resources (Edwards 2000). Once the economy starts to expand rapidly, a series of factors constrains wastewater-fed aquaculture:

- increasing shortage and value of periurban land
-declining quality of wastewater as a nutrient source
-increasing and changing demands of more affluent consumers (for large and often carnivorous species of fish even though these are higher priced than wastewater-fed fish)
-ability of farmers to meet the demand for alternative farmed species because of availability of seed through R&D, rice bran and oil cakes, and pelleted feed from agro-industry.

Even in China, which has the longest tradition and had until recently the largest extent of wastewater-fed aquaculture, the practice is disappearing. Wastewater-fed aquaculture was banned in China in the 1990s because fish raised in such systems contain contaminants from industrial wastewater. Nobody likes to eat fish which smells and tastes of industrial chemicals such as phenols. As the living standards of Chinese people are improving constantly, the government is developing a movement for safe, healthy food production that includes a system of licensing and inspection.

Considering recent developments in China, Bangladesh and Vietnam, and the various constraints outlined above, it is difficult to end on a positive note regarding the future of urban wastewater-fed aquaculture. However, Vietnam has many smaller cities which are at an earlier phase of development than Hanoi; wastewater treatment and reuse through aquaculture occurs and has relevance there, at least for the near future. Despite the pressing need for low-cost wastewater treatment, and the employment opportunities and relatively cheap food produced in reuse systems for the poor, it is unlikely that such land-intensive systems will be implemented in Bangladesh. Perhaps aquaculture wastewater treatment and reuse systems could become an integral part of green belts required to make the periurban areas of rapidly expanding cities socially as well as environmentally sustainable? This would depend on the benefits of wastewater-fed aquaculture being appreciated by urban planners and sanitary/ environmental engineers. There is little evidence that this is likely in the near future.

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