PONDS REDUCE WASTES

Rowan Shirkie

Waste not, want not — the phrase has taken on a whole new meaning in these times of resource scarcity and environmental crises. A global effort now being mounted in Israel, Kenya, Malaysia, Peru, and Thailand will research ways of reclaiming and reusing one of the most precious and threatened of the world's resources. . .water. Under investigation is a system of wastewater treatment that combines low-cost sanitation with food production by using waste treatment ponds to raise fish.

Over the next two years, institutions in the five countries will be conducting experiments with waste stabilization ponds that exploit the natural action of bacteria and algae to remove human and industrial wastes from water. Researchers will also study the treatment and fish production capabilities of various types of these ponds under different conditions, with the health aspects of the system being given a special priority.

Waste disposal presents a considerable problem in rural and urban towns in developing countries, particularly those that cannot bear the high cost burden of the sort of treatment methods common in industrialized countries. Water scarcity, and growing concern over the health hazards and environmental damage created by inadequate collection and treatment of human and industrial wastes have further spurred the search for low-cost alternatives. Considerations of reuse or reclamation are beginning to become more and more important in the decisions to adopt types of disposal systems.

Stabilization ponds represent one of the best alternatives. They are efficient, relatively inexpensive to construct, and easy to maintain. Their mode of operation, which depends on favourable warm temperatures and full sunlight make them ideally suited to tropical countries. These characteristics, together with the potential for actual economic returns when given an extended use with aquaculture, make the system seem an unbeatable combination.

There are two areas to be investigated more fully before the potential of aquaculture in stabilization ponds can be realized on any large scale. The first involves health considerations — the need to eliminate or block any possible transfer of disease-causing organisms, pesticides, or heavy metals through the ponds by the fish raised in them. The second is one of design and operation. Ways of adapting ponds to accommodate aquaculture must be investigated.

Pollutants in wastewater can be changed by biological, physical, and chemical forces. Unstable organic wastes can be transformed into inoffensive substances by these agents; in other words, stabilized.

Organic material in stabilization ponds is decomposed by two bacterial processes: aerobic and anaerobic. Bacteria digest organic matter in wastes, converting it to energy and growing new cell material. Aerobic bacteria require oxygen to grow, whereas strictly anaerobic bacteria cannot grow in the presence of oxygen. The "wastes" or byproducts of this bacterial action are gasses, inorganic, and organic compounds such as carbon dioxide, ammonia, organic acids, etc.

Aerobic bacteria prefer the surface layers of a stabilization pond, where they can obtain oxygen from the plant activities of algae. In addition to supporting the aerobic bacteria, algae also contribute to the stabilization process by using bacterial byproducts for their own growth.

Anaerobic bacteria exist in and near the bottom layers of the pond, where the heavier organic load of settled waste solids and the absence of oxygen provide the proper environment. Thus the type of stabilization pond most commonly used for waste treatment employs both aerobic and anaerobic action.

Although the initial treatment received in a pond removes many of the pollutants from wastewater, fecal bacteria and a range of viral and parasitic organisms still persist. Often a secondary pond, or series of maturation ponds are employed to further treat wastewaters before they are discharged. A properly operated stabilization pond system can remove more than 98 percent of the fecal coliforms in the wastewater. The majority of these micro-organisms die off under the hostile, competitive conditions of sunlight, temperature, lack of nutrients, and other predatory organisms in the ponds. A general rule of thumb in treatment is that the longer a wastewater is detained in a pond system, the greater the destruction of these pathogens. It is in the secondary and maturation ponds that researchers will conduct aquaculture experiments.

Fish farming based on ponds fertilized by human and animal waste has added millions of tons of food to the diets of people in Asia, where the techniques have been refined over centuries of practice. Adding fish to waste ponds instead of waste to fish ponds makes no radical departure from this widespread and well-understood traditional technology.

Wastes were traditionally added to aquaculture ponds as fertilizer to increase the production of algae, on which the fish subsequently fed. The most popular varieties of fish cultured in this way are Carp and Tilapia. Both grow rapidly under a variety of conditions, and offer high productivity levels. Carp yields of over 1000 kg/ha-year and Tilapia yields of over 2500-3000 kg/ha-year are often reported. Mixing species of fish with different feeding habits — polyculture — allows full use of the range of nutrients available in waste-fed aquaculture ponds: bottom feeders to feed on bottom detritus (waste residues), with phytophanktophagic fish that can strain out microscopic algae from the water and harvest the byproducts of the

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waste decomposition process in the upper layers of a pond.

Fish do not seem to be susceptible to infection by the same pathogenic bacteria present in wastes and wastewaters that cause disease in humans. They may however, carry some of these pathogens on their scales, or as undigested material in the gut. Some fairly simple procedures to remove this danger, such as holding fish in clean water for a time, cleaning and thorough cooking, will be tested as part of the present research effort. There are indications that the presence of fish in treatment ponds can improve the quality of the water. Aside from the direct action in removing wastes and algae from ponds through feeding, fish indirectly affect the stabilization processes. Removing algae by feeding changes the algae-bacteria relationship and the dissolved oxygen content in the water. Fish thereby join the food chain in a reaction that eventually causes a change in the water's chemistry, making it a still more hostile environment for pathogens.

However, much remains to be discovered about the effects and modes of transmission of heavy metals and pesticides that may be present in industrial wastewaters or waters polluted by agricultural runoffs. There is evidence to show that the toxic materials present in such wastes may accumulate in the tissues of fish that ingest them, and can be passed on to humans. Specific research in Kenya will examine the effects of wastes from a tannery industry on the performance of a stabilization pond system, and on the fish raised in it.

There are well-recognized hazards associated with wastewater reuse for irrigation purposes. The persistence of pathogens even in treated wastewaters may restrict its use in agriculture, as the pathogens survive to infect humans eating food crops. The health hazards to farm workers handling wastewaters are obvious. There is an additional danger of damaging the soils under wastewater irrigation, either through accumulation of heavy metals, or salts build-up that affects fertility. The prospects for irrigating non-food crops (thus largely eliminating the transfer of pathogens) such as cotton, tobacco, or trees are promising, and further research may develop this area of reuse.

The stabilization process and conventional pond design must be adapted to accommodate the different requirements of aquaculture and wastewater treatment. Stabilization ponds have been designed to achieve maximum treatment efficiency. Yet successful aquaculture would depend on adequate supplies of nutrients being present, nutrients that are the wastes and algae stabilization ponds are working to remove. Future designs must strike an operating balance between two uses.

Just as too little food in the pond would hurt fish production, the sudden influx of large quantities of raw wastes could kill off a fish crop, either by introducing very toxic materials, or by causing the stabilization process to accelerate rapidly and exhaust all the available oxygen in the water. Because very little is actually known about an integrated stabilization/aquaculture system (although over the years a significant body of knowledge has grown up around the two independent techniques), much of the research being undertaken now is still basic.

The University of Malaya in Kuala Lumpur will use two existing ponds currently receiving domestic wastewater from a nearby housing estate, and construct four other ponds particularly for their experiments. The existing ponds will be subdivided and stocked with different combinations of fish at different rates, and the university team will begin a detailed study of the extended food chain created in the ponds. The experimental ponds will be fed "nightsoil" collected from low-income residential areas of the municipality. Maturation ponds receiving the treated effluent will be stocked with fish. In the Malaysian experiments, particular attention will be paid to the levels of pathogenic bacteria and parasites in the raw wastes, the ponds at various stages, the fish, and the treated effluent. Part of the project includes a survey of the traditional practice throughout Malaysia and Indonesia of dumping wastes in small household or village ponds, to determine their health and production characteristics.

In Israel, the Fish and Aquaculture Research Station of the Agricultural Research Institute at Dor will use four maturation ponds treating domestic wastes from a community of about 5,000 inhabitants. Researchers will study the effects of different rates of waste loading, and fish stocking and density rates. They will also study various aspects of the waste stabilization/fish production system under temperate climatic conditions, and the potential use of an aquatic weed (Lemna or "duckweed") for enhancing the treatment processes and providing supplemental fish feed.

In Kenya, research on five pond systems will be carried out by the Research Unit of the National Water Laboratory, Water Quality and Pollution Section, Ministry of Water Development in Nairobi. The ponds the Kenyan team will study represent a variety of loading conditions and treatment processes, including the treatment of mixtures of industrial and domestic wastes. One experiment will culture surface-breathing fish under highly-loaded, oxygen-deprived conditions. A special interest of this research will be in the concentrations of heavy metals and chlorinated hydrocarbons in the flesh of fish and other organisms raised in industrial wastes.

In Peru, the Pan American Center for Sanitary Engineering and Environmental Sciences in Lima will evaluate the performance of an existing stabilization pond system, with the aim of developing design criteria for different loading and climatic conditions in Latin America. The Center will focus primarily on the potential for reclamation and reuse of wastewater in irrigation. The health aspects of wastewater irrigation will be a main concern, but the project will include studies on aquaculture and the impact on soils.

In Thailand, the Environmental Engineering Division of the Asian Institute of Technology (AIT) in Bangkok will use 16 fish ponds stocked at four different rates and maintained at four different algal feeding rates. The effluent from a high rate (primarily anaerobic) stabilization pond receiving wastes from the AIT campus will be fed into the fish ponds. As in the other experiments, the Thai team will closely monitor the characteristics of the fish and treatment at all stages, looking for means to design pond operations to optimize both fish production and wastes treatment. They will focus on the economic and engineering factors that would influence the system's usefulness to rural and urban areas of Thailand and tropical Southeast Asia.

Each project has its own expertise in the fields of economics, aquaculture, and sanitary engineering, and each will emphasise a different element of wastewater reclamation. Yet the research methods and the analytic techniques used to interpret the findings must be standardized in order that the results can be properly compared and built into a useable, comprehensive body of scientific information. At the same time, researchers must be kept abreast of any pertinent developments in one project or another. A program of training sessions and meetings that will bring researchers together to establish common methodology and exchange information is therefore an important part of the global research effort.

From a planner's or sanitary engineer's point of view, the stabilization pond as a method of waste treatment has the advantages of being efficient, economical, flexible in scale and operation, and well suited to the tropical conditions of many developing countries. But if they can be combined with fish farming or other agricultural activities, stabilization ponds may have another advantage more important than any of these others. For the people whose everyday lives would be changed, such ponds could make the advantages of proper collection and treatment of wastes as obvious and concrete as more food on their tables and more money in their pockets. The cooperation and support at the community level that this particular technology might be able to attract as a result make it much more likely to be able to deliver health and development benefits long after the planners and engineers have finished their work. □