Wastewater Use in Aquaculture: Research in Peru

Use of wastewater is an issue gaining importance throughout the (developing) world, as water sources become scarcer and competition for them increases. In Peru, research has shown the technical, economic and social feasibility of growing fish in wastewater. Such fish farms could recover 100% of the wastewater treatment costs.

Due to the rapid population expansion and water scarcity in most cities of developing countries, there is a need for reusing wastewaters for productive activities that help cover the treatment costs. If these operations become profitable, it would be possible to extend the sanitary coverage in a belt around the cities, as well as to extend the farming area and improve the use of water, especially in arid zones.

Uncontrolled spillage of wastewater into natural environments is considered to be one of the most harmful forms of pollution. The deterioration of sanitary conditions is also one of the most negative effects of this practice. Only a few of the largest cities in developing countries have wastewater treatment systems, some operating beyond their capacity, while others are not operational at all because of technical restrictions.

In Latin America around 400 m^3/second of untreated wastewater are being disposed in surface waters and used in the irrigation of about 500,000 ha of land, causing health problems and environmental contamination. To change this situation, wastewater treatment must be increased, and, from a sanitary point of view, its reuse should be safe, but in accordance with the poor economics of developing countries. This reuse would generate new food and job sources, expand the agricultural frontier, and improve the use of water.

The rearing of fish in wastewater-fed ponds is a common practice in some Asian countries. Although interesting for the generation of food at the same time that wastes are treated, this scheme is not advisable from the sanitary point of view for the risk that fish becomes a vehicle for disease transmission to humans.

The Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (CEPIS) undertook a series of experiments to investigate the biological and socioeconomic feasibility of further treating wastewater and then using it for fish production.

In the project, the possibility of improving these systems by treating the wastewater prior to its use in aquaculture was studied. A fish farm was built to receive tertiary effluents of a battery of stabilization lagoons at San Juan, located south of Lima. The research program consisted of experiments with Nile tilapia (*Oreochromis niloticus*) from July 1988 to April 1990.

Waste Quality and Human Health Aspects

A complete set of water quality, biological and sanitary parameters were regularly monitored in the treatment systems, fishponds and the fish. At the end of the research program, it was concluded that the treatment system could be configured to obtain a water quality level suitable for aquaculture.

In order to minimize the risk of contamination in the fish muscle and allow its consumption by people, the study recommended that the maximum level of fecal coliforms in the fishponds should be 1×10^4 MPN/100 ml and that this level could be achieved by using stabilization effluents with fecal coliform concentrations under 1×10^5 MPN/100 ml.

Aspects such as stabilization, pond

Experimental fishponds built within the municipal wastewater treatment plant area consisting of stabilization ponds. The township of San Juan is visible in the background. ALL PHOTOS BY MARK PREIN, ICLARM.

Box 1.

CEPIS

CEPIS, the Pan-American Center for Sanitary Engineering and Environmental Science, is to be commended for successfully performing this multidisciplinary project. It provides important information and insights called for in the major texts on wastewater-fed aquaculture (Edwards 1992; Edwards and Pullin 1990).

ICLARM researchers were fortunate to have been involved in various aspects of this important project. Before it began, Roger Pullin and Daniel Pauly were invited to participate in the Expert Panel advising the project, led by Peter Edwards of the Asian Institute of Technology.

At the first meeting in Lima in 1986, Daniel Pauly and the late Balfour Hepher of the Fish and Aquaculture Research Station in Dor, Israel, discussed possible new approaches to analyze the large amounts of data that were to be collected in Lima. The result was a joint BMZ-funded project whose outcome was a volume of methods and case studies on multivariate statistical analyses of large datasets from aquaculture experiments and commercial farm operations (Prein et al. 1993). Some of these methods were introduced to the project and applied in the analyses (part 3 of the report), providing important insights.

The project leader, Julio Moscoso and a further aquaculture researcher of the project Hugo Nava, were invited to ICLARM and were introduced to a range of tilapia hatchery and culture systems thriving in the Philippines and Thailand.

Another ICLARM researcher, Max Aguero, provided advice for the socioeconomic studies conducted within the project. These studies make the research project particularly valuable, as economics are often neglected and in this case provided data and relationships for use by policymakers.

The semi-arid conditions in Lima do not prevent the results from being useful for situations in more favorable, humid conditions. Likewise, the difficult economic circumstances prevailing during the project required extra, beyond-normal efforts by project staff. The strong support and coordination provided by Carl Bartone of the World Bank and the former CEPIS Director, Alberton Florez, made the project possible and the unflagging support by the donor, GTZ.

This set of four reports deserves wider circulation and readership. I therefore hope that these will be translated into English and French so that the information can reach a wider audience, also in Africa and Asia. ***Mark Prein, ICLARM***

design and operation were detailed, together with their implications for sanitary aspects.

Fish Production

Sex-inverted male populations of Nile tilapia with initial weights between 13 and 77 g were reared at stocking densities ranging from 0.2 to 5 fish/m² for periods of 112 and 154 days. Supplementary feeding based on wheat and rice bran was also tested.

In the subtropical climate of Lima, only one production cycle was possible per year. The best production system was stocking 60 g of Nile tilapia juveniles at a rate of 2 fish/m² to obtain a commercial size of 250 g in four summer months. The carrying capacity of the ponds was determined to be 4,410 kg/ha. Productivity rate was 30.8 kg/ha/day without any supplementary feeding.

Socioeconomics

The biological results were applied to a commercial scale fish farm, located in the same subtropical context in the Ventanilla subdivision of Lima.

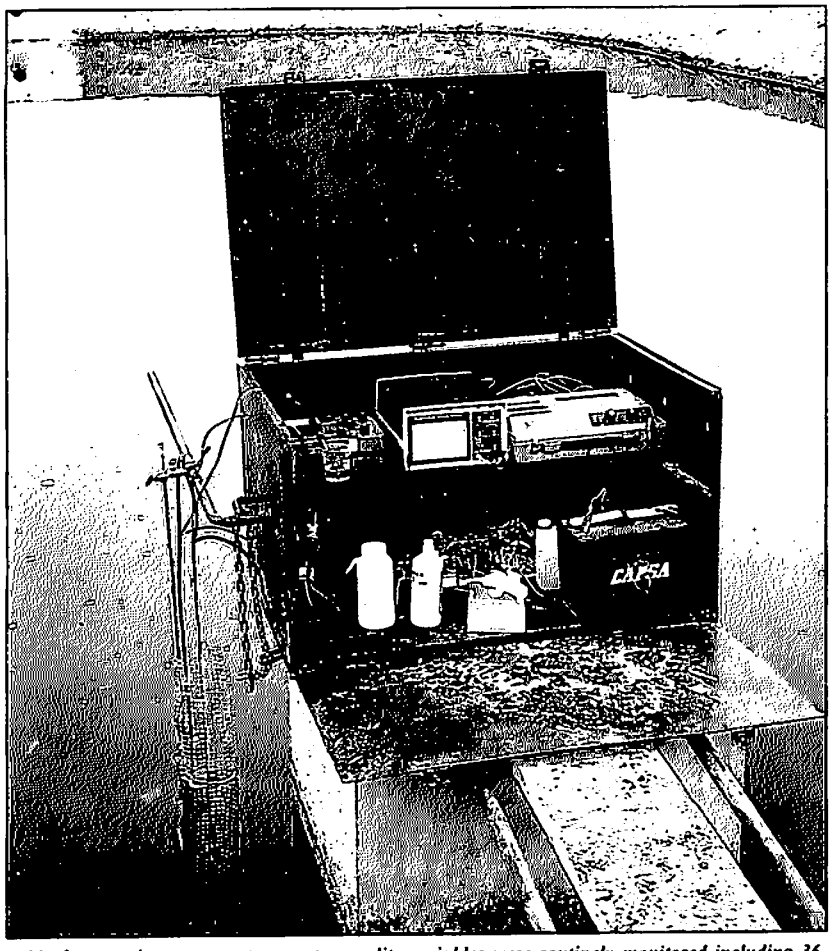
Market research demonstrated that tilapia is an appropriate substitute for commonly consumed marine species in the "white meat" class, such as "cojinova" (*Seriollela violacea*), and "chita" (*Anisotremus scapularis*). According to the sale prices, however, tilapia replaces species such as "jurel" (*Trachurus simetricus murphi*), "bonito" (*Sarda sarda chilensis*) and "lisa" (*Mugil cephalus*). Estimated sale price for this new product may fluctuate between US$0.80 and US$1.00/kg. The weight recom-mended for sale purposes is 250 g/piece, comparable to many other species being sold in Lima. The estimated potential market absorption capacity may be 180 tonnes/month and may increase by 3.6 t annually. There was no evidence of refusal to eat the products, after consumers were made aware of its origin (culture in earthen ponds irrigated with treated wastewater).

In tropical environments, perhaps three production cycles could be obtained annually, thus reducing the production cost from US$0.40 to $0.31/kg.

The economic analysis suggested that these waste-water fed integrated systems have great potential to achieve high economic viability (here expressed as Net Present Value, NPV) in tropical and subtropical contexts. However, tropical conditions seem to be better suited. For example, a farm in subtropical conditions such as Lima, of about 16.2 ha with a capacity for the production of 52.8 t/year has a NPV of US$46,400 at a 21.8% discount rate, while in tropical conditions, a farm of about 9.0 ha and an annual production of 63.4 t/year, has a potential NPV of US$95,200.

The fish farm could recover 100% of the wastewater treatment costs, which are around US$0.0062/m³ for a treatment plant in Lima

Nile tilapia were sampled biweekly for length and weight.



Aside from sanitary parameters, water quality variables were routinely monitored including 36-hour dissolved oxygen recordings with a battery powered strip chart recorder.

with 100 l/second raw inflow. In tropical conditions, the wastewater treatment cost is around US$0.0042/m^3, which is more easily financed by the fish production activity.

It is important to emphasize that the high levels of organic substances recovered from the stabilization lagoon effluents can be used to reduce the production costs of agricultural activities, including aquaculture. This constitutes an advantage over other methods of pollution control. ***[Compiled by Mark Prein from the abstracts of publications, Box 2]***

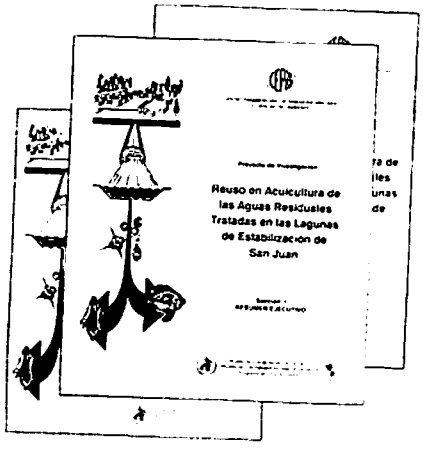
Further Reading

Edwards, P. 1992. Reuse of human wastes in aquaculture: a technical review. Water and Sanitation Report 2. UNDP-World Bank Water and Sanitation Program, The World Bank, Washington, DC, USA.

Edwards, P. and R.S.V. Pullin, Editors. 1990. Wastewater-fed aquaculture. Proceedings of the International Seminar on Wastewater Reclamation and Reuse for Aquaculture, Calcutta, India, 6 to 9 December 1988. Environmental Sanitation Information Center, Asian Institute of Technology, Bangkok, Thailand. 296 p.

Prein, M., G. Hulata and D. Pauly, Editors. 1993. Multivariate methods in aquaculture research: case studies of tilapias in experimental and commercial systems. ICLARM Stud. Rev. 20. 221 p.

Box 2.



Reuse of treated effluents for aquaculture in the stabilization ponds of San Juan, Lima, Peru

The complete set of publications described in the article above are listed below. This four-volume set (in Spanish) costs US$25.00 plus postage. For more information, contact:The Director, CEPIS, Casilla Postal 4337, Lima 100, Peru; Tel. No.: +51-1-4371077, Fax No.: +51-1-4378289, Email: cepis@cepis.org.pe

Moscoso Cavallini, J. and A. Flórez Muñoz. 1991. Reuso en Acuicultura de las Lagunas de Estabilización de San Juan. Seccion 1: Resumen Ejecutivo. Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (CEPIS), Lima. 35 p.

Moscoso Cavallini, J., G. Léon Suematsu, E. Gil Merino and A. Flórez Muñoz. 1992. Reuso en Acuicultura de las Lagunas de Estabilización de San Juan. Seccion 2: Tratamiento de las Aguas Residuales y Aspectos Sanitarios. Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (CEPIS), Lima. 70 p.

Moscoso Cavallini, J., H. Nava and A. Flórez Muñoz. 1992. Reuso en Acuicultura de las Lagunas de Estabilización de San Juan. Seccion 3: Acuicultura, Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (CEPIS), Lima. 70 p.

Moscoso Cavallini, J., H. Nava and A. Flórez Muñoz. 1992. Reuso en Acuicultura de las Lagunas de Estabilización de San Juan. Seccion 4: Factibilidad Tecnica, Economica y Social. Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (CEPIS), Lima. 78 p.

OLDEPESCA

OLDEPESCA (Organizacion Latino Americana de Desarollo Pesquero) or the Latin American Fisheries Development Organization, was created in November 1982 by twelve countries of Latin America and the Caribbean. It was first set up as the action committee of sea- and freshwater products of Sistema Economico Latinoamericano (SELA), which was later replaced by OLDEPESCA, as a means of progress towards the most advanced forms of regional cooperation in the activity of fishing. Described below are its objective and activities.

Currently, OLDEPESCA has ten member-countries and two participants, two in the process of joining, and twenty observers including international bodies such as the European Union.

Its main purpose is to promote sustainable fishing development in Latin America and the Caribbean, as a means of contributing to solving the food and employment problems affecting the region. Concurrently with this basic objective, it also has the following responsibilities in the different areas of fishing:

- to promote adequate sustainable use of fishing resources, compatible with the conservation of the same and of the local environment;
- to promote a substantial increase in the supply of fish products putting these within reach of the great majority of the inhabitants of the region, to strengthening regional food security;
- to encourage the increase and diversity of fish exports;
- to promote interregional trade in fish products;
- to encourage the generation of jobs and an improvement in incomes through a greater socioeconomic development of the communities linked to fishing activity in the region;
- to encourage the improvement of fishing management capacity by means of the efficient training of human resources; and
- to promote and organize the use of the joint bargaining capacity of the region.

Dr. Carlos Mazal, Executive Director of OLDEPESCA, and Ing. Jaime Sobero Taira, Peru Minister of Fisheries, during the 10th Conference of Ministers of OLDEPESCA, 8-10 March 1994, in Lima, Peru.

Throughout its lifetime—ten years—OLDEPESCA has been promoting responsible fishing development and fishing integration, creating practical and permanent interdependency among its members and other regions of the world, based on mutual necessities and interests. The first stage has been accomplished and today, OLDEPESCA faces the challenge of consolidating its position to make dynamic the process of cooperation and by this means, reach the concrete successes demanded by the inhabitants of the region.

The European-Latin American Cooperation in Fishing

As has been said, the region of Latin America and the Caribbean has one of the richest fisheries in the world in both the volume of its biomass and the great variety of species found in its coastal and inland waters.

Catches in the region, which reach some 18 million tonnes, constitute approximately 18% of the world total. Due to the great potential of its resources and still low technological level, the region's fisheries can continue their expansion.

There has been a growing interest in Europe, in the last few years, in the fishing development of the region, verified by cooperation agreements presently in effect. As a result of the first technical consultation on fishing in the Central American Isthumus, held in 1984 within