# ENVIRONMENT

*Technological Innovation*

## ABSTRACT

Bio-Aqua Technologies has developed a system for treating and recirculating water from fish rearing facilities with the aim of reducing the impacts of pisciculture on water availability and on the quality of the aquatic environment. This technology solution consists of an exportable combination of equipment and know-how designed to respond to the needs of high-density fish rearing systems in a controlled commercial setting.

Bio-Aqua technology is a tool that enables fish culturists to reduce water consumption substantially (90% of the water is recycled), eliminate discharges of untreated effluents and improve effluent quality, bringing it into line with environmental requirements. The technology is also responsive to the competitive demands of the aquaculture industry, especially given the higher productivity levels that are attained.

## AGRI-ENVIRONMENT

### BIO-AQUA: SYSTEM FOR TREATING AND RECIRCULATING WATER FROM FISH REARING FACILITIES

## HIGHLIGHTS

**Technology**
- Solids removal by a rotating screen
- Low temperature biological treatment (biotower) coupled to a degassing ($CO_2$) and ozonization system
- Operations control system

**Environment**
- 90% reduction in water consumption
- Elimination of untreated effluent discharges to the natural environment
- Reduction of over 95% in BOD, nitrogen and phosphorous in effluents and decrease of almost 90% in TSS
- Optimized management of organic waste and biological sludges that are generated

**Cost-effectiveness**
- Increase in productivity and stable year-round production
- Quebec and Canadian aquaculture will be more competitive

Canada

SM | BioAqua Technologies

Volet Environnemental du FPGST-E
Québec Ministère de l'Environnement
Québec Industrie et Commerce

# PROJECT OBJECTIVES/ PHASES

***Bio-Aqua*** **project was undertaken to find a technological solution to some environmental problems faced by the fish culture industry in Quebec and Canada.**

**The objective of the project was to carry out, validate and optimize the design of an integrated system for treating and recycling the water from fish rearing operations. An experimental system was therefore designed and tested under actual operating conditions with the requisite quantity of fish (biomass density) for commercial production.**

**During the experiment, all process variables, including feed regime, presence of bacteria and parasites, physico-chemistry of the water, water quality in the rearing tanks and photoperiod, were controlled. The management chains for the water and sludges were also studied and improved as a function of discharge control criteria, while ensuring that optimal conditions for fish growth were maintained.**

**Experimental protocols were used to define suitable procedures for monitoring and analysing the quality of the recycled water and the discharges. Guidelines necessary for maintaining a continuous operating regime were likewise defined.**

# BACKGROUND

Around the world, various restrictions have been imposed on commercial fisheries targeting a variety of fish species, and this situation has provided an impetus for aquaculture, which represents a promising avenue for increasing and diversifying fish supply.

In Quebec, industry growth is currently restrained by the need to apply sustainable development principles and environmental quality standards.

Land-based fish farming facilities and operations represent a source of pollution for natural receiving waters, owing to suspended solids, biological oxygen demand and nitrogen and phosphorous levels in the effluents discharged to the environment. In Quebec, fish farms account for the largest groundwater withdrawals, after residential use. Given the large volumes of water used, it is challenging to devise biological or physico-chemical treatments for effluents.

Because of the highly competitive market and the strict environmental requirements, fish culturists in Quebec and Canada need to find new avenues for development that address these considerations, if they want to compete successfully at the national and international levels.

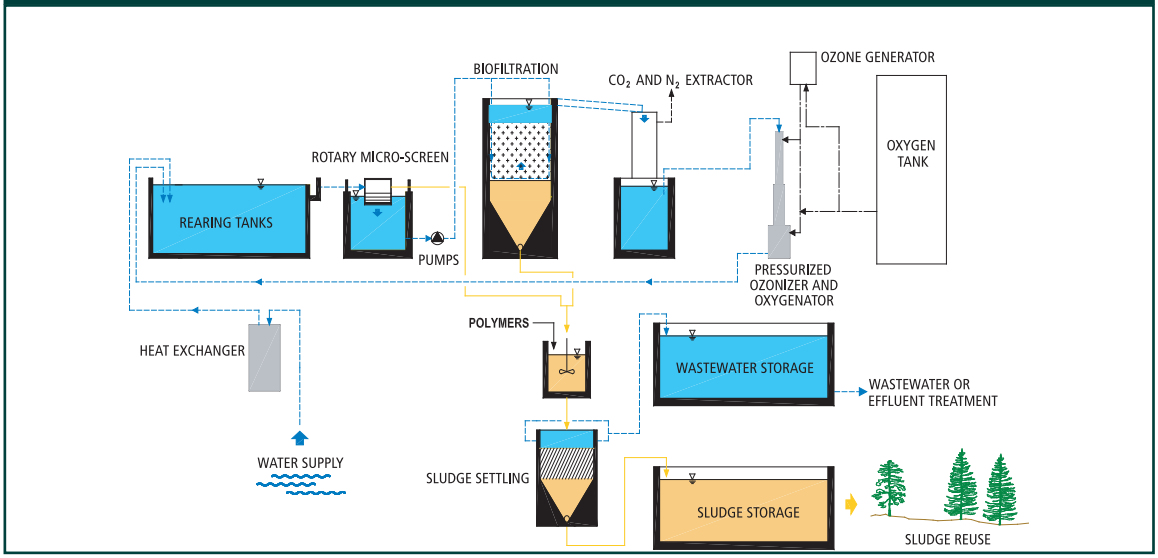
# TECHNOLOGY

Bio-Aqua technology has a treatment train designed to reduce pollutant loading and meet water quality criteria, while ensuring that optimal biomass growth is maintained.

The main components of the treatment train are the rotary filter (mechanical treatment), the biotower (biological treatment), the degassing tower ($CO_2$), the ozonizer and the oxygenation system.

The technology also calls for the use of a clarifier and a settling tank for sludge removal.

## BIOAQUA TECHNOLOGY




## BENCH-SCALE CHARACTERISTICS OF THE BIO-AQUA SYSTEM

| Temperature | pH | Dissolved Oxygen (mg/L) | Recycle System Flow Rate ($m^3/h$) | Optimal Flow Rate in Biotower ($m^3/h$) |
|---|---|---|---|---|
| 11 ± 1 °C | 6.5 - 7.5 | 9 - 11 | 45 | 15 |

# RESULTS

The Bio-Aqua Technologies project involved designing an experimental production unit encompassing all the equipment required to treat and recycle water and collect residual sludges from two rearing tanks. Two fish species were involved in the testing phase of this project, namely Arctic charr (Salvelinus alpinus) and rainbow trout (Oncorhynchus mykiss). The experimental system consisted of two fibreglass tanks measuring 21.3 metres long by 1.5 metres wide and 1.5 metres high. This system was operated under actual production conditions over a 45-month period, in accordance with carefully defined experimental protocols and using the quantity of fish required for commercial production. Production conditions were nonetheless varied in order to assess the results as a function of different biomass densities. The sludges were routed to the City of Sherbrooke's municipal treatment plant, in compliance with the certificate of authorization from the ministère de l'Environnement du Québec.

During the study, a variety of parameters were measured and some elements were optimized to improve the system's environmental performance and cost-effectiveness. The experiment made it possible to:

- establish protocols for operating the biotower;
- improve the rotary filter and the ozonization system;
- optimize the self-cleaning efficiency of the tanks;
- determine optimal operating parameters and control the process variables;
- evaluate the maximum biomass density permitting optimal growth of the species under study.

Furthermore, the system demonstrated effective management of $BOD_5$ (95%), TSS (88%), total nitrogen (97%) and total phosphorous (95%). In continuous operation, the system treats water in such a way that these elements are held at stable levels on a daily basis (no accumulation occurs in the rearing tanks).

**PARAMETERS MEASURED**

| Parameters | Measurement |
|---|---|
| % Water Recycling | 85-90% |
| Maximum Biomass Density | Arctic charr: 115 kg/m$^3$<br>Rainbow trout: 40 kg/m$^3$ |
| Growth Rate | Arctic charr: 4.3%/week<br>Rainbow trout: 8.8%/week |
| Time required to obtain commercial size fish | Less than 12 months |

**PURIFICATION PERFORMANCE OF BIO-AQUA SYSTEM (WATER MANAGEMENT CHAIN)[1]**

| Parameters | Mechanical Cleaning of Accumulation Zones (% Removal) | Mechanical Treatment (% Removal) | Biological Treatment (% Removal of Residual Materials) | Average Yield of System as a Whole (%) |
|---|---|---|---|---|
| Total suspended solids (TSS) (mg/L) | 15 | 60 | 34 | 88 |
| Five-day biological oxygen demand ($BOD_5$) (mg/L) | 7 | 30 | 83 | 95 |
| Total nitrogen (mg/L) | 2 | 14 | 95 | 97 |
| Total phosphorous (mg/L) | 8 | 74 | 50[2] | 95 |

[1] Results based on the analysis of weekly measurements taken during continuous operation of the facilities (about 20 months).
[2] Part of the phosphorous accumulated in the biotower.

# POTENTIAL AND LIMITATIONS

**Potential**

- Substantial reuse of treated water (90%)
- Reduction in freshwater consumption
- Elimination of untreated effluents to the natural environment
- Faster rearing of fish to commercial size
- Stable growth rate year-round
- Optimal stocking density
- Optimal conversion rate
- Potential for adapting the system for other cold or warm-water species
- Development of aquaculture sites in locations where water availability is a limiting factor.

These factors help to increase the potential for establishing new fish farms and enhancing the competitiveness of Quebec and Canadian aquaculture operations.

**Limitations**

The Bio-Aqua system requires a larger up-front investment than open or flow-through systems. This is, however, largely offset by the savings that can be achieved through higher productivity in the rearing tanks.

# INFORMATION

This data sheet is based on the final report prepared by Bio-Aqua Technologies Inc, in the project to develop a technology for treating and recirculating water from fish rearing facilities. The project was funded by the National Research Council of Canada, Canada Economic Development and the Quebec government's science and technology priorities fund.

For additional information, please contact:

**Environment Canada**
**Innovation, Monitoring and Industrial Sectors**
Jean-René Michaud,
Eng, M.Sc.A.
Tel: (514) 283-9207
Fax: (514) 496-2901
E-mail:
jean-rene.michaud@ec.gc.ca

**Bio-Aqua Technologies inc.**
Gérard Laganière, Eng.
Tel: (819) 566-8855
Fax: (819) 566-0224
E-mail:
glaganiere@smnetcom.com
Web site: www.groupesm.com



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**Production:**
**Julie Leduc**

**Writers:**
**Julie Leduc**
**Gérard Laganière**
**Kathy Dumaresk**
**Jean-Pierre Réville**

**Reviewer:**
**Monique Simond**

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