Adequate Application of Various RAS Designs in Aquaculture

Adekvatna primjena raziličitih RAS dizajna u akvakulturi

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The aquaculture industry cannot expand to the levels necessary to meet demand and legal scrutiny without an investment in more efficient technologies and management methods.

Direction of development of new technologies

- Profitability of production and distribution of the final product
- Creating a bankable business
- Human health and safety
- Environmental protection and water consumption reduction
- Welfare of cultivated organisms

Recent recommendation to move towards sustainability

- Move aquaculture offshore - enables more efficient dilution of the waste produced from the farm (high capital cost and just a partial solution for the pollution)
- Utilize multi-trophic aquaculture -reducing nutrient build-up simply using filter feeders (system is usually not very profitable, and difficult to balance and control)
- Reduce long-term operating costs and increase competitiveness and profitability
- Move aquaculture inland – recirculating aquaculture systems

Indoor Recirculation Aquaculture Systems

- The growing need for food and the preservation of the environment dictates an increasing need for changing designs of cultivation systems
- Recirculating Aquaculture Systems minimize water usage and land requirements
- Limited volume of wastewater can be economically treated for the removal of both solid and dissolved waste
- Controlled breeding environment during the whole growing period shortens the production cycle

RECIRCULATING AQUACULTURE SYSTEM TECHNOLOGY

has been under development and refinement for the past 50 years. After the initial research phase the primary focus has been to create, develop, and refine recirculating technologies that can produce food fish on an economically competitive basis.

Development of RAS design

- The high market price, inadequate design and the fact that it is a closed system involving a solid building required capital costs that made most recirculating aquaculture projects unprofitable.
- In the last ten years, the components of recirculation systems have become cheaper thanks to mass production and simplified constructions, and a significant part of the complete systems has been adapted to the cultivation of various types of aquatic organisms, with the involvement of competent aquaculture experts.
- At the same time, the accumulated experiences enabled the development of new creative, simplified and financially justified designs.
- In the last few years, in Europe, including in Croatia, there has been a significant increase in interest in including RAS in fish farming projects.

Recent involvement of financial institutions and failures of large systems

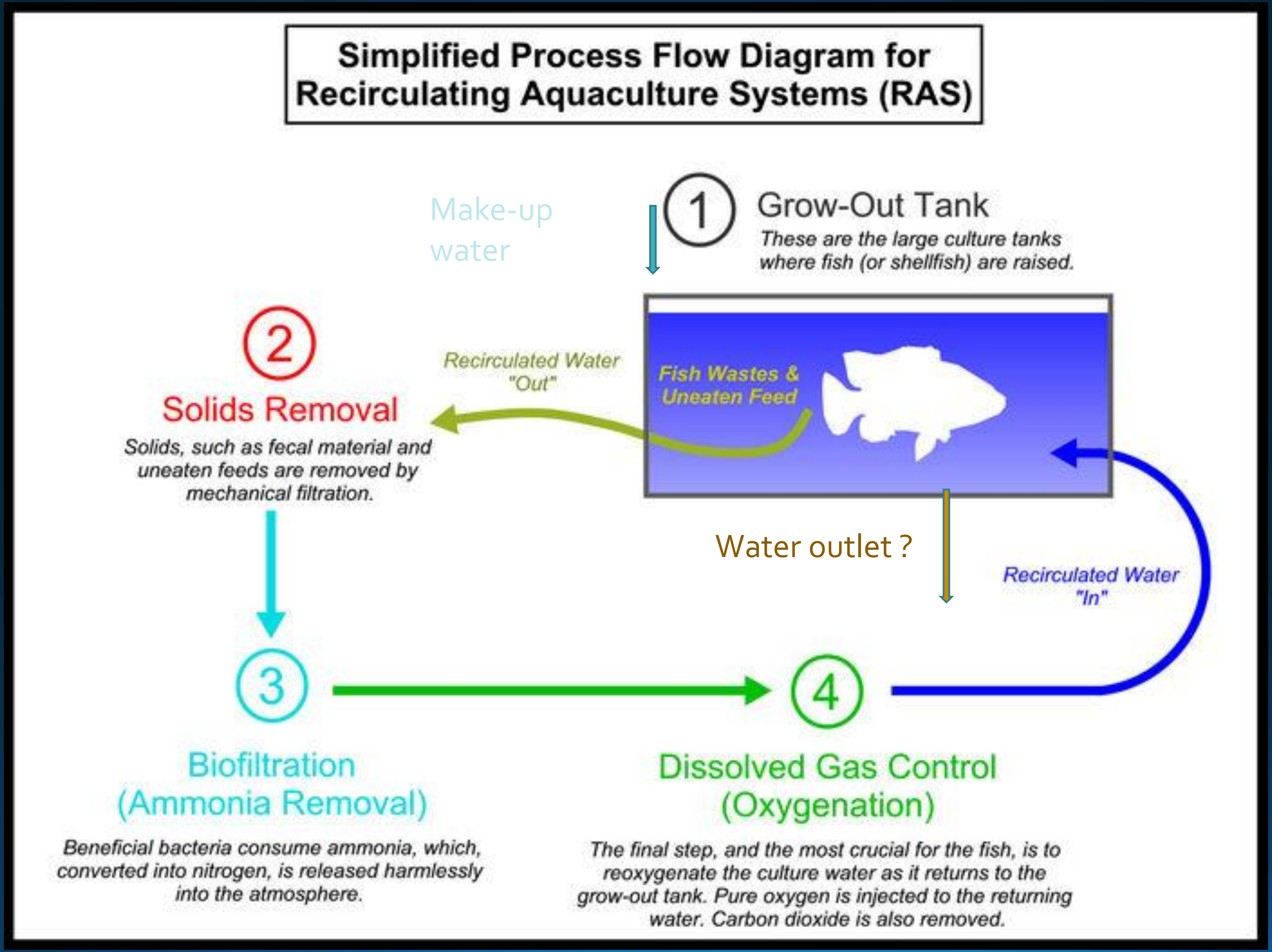
- The Norwegian DNB Bank and the Rabobank from The Netherlands have both agreed that land-based indoor fish farming will become one of the major growth industries in food production. DNB ASA is Norway's largest financial services group with total combined assets of more than NOK 1.9 trillion and a market capitalisation NOK 164 billion. The emphasis is on volume of production, to achieve the economies of scale necessary to make operations profitable.
- Atlantic Sapphire and Pure Salmon. Both had a showcase facility; both companies raised huge amounts of equity funds. Demonstration facility in Europe during the construction of Atlantic Sapphire facility in Florida expressed some difficulties in management and design.
- Meanwhile, Pure Salmon lost their facility in Poland as a showcase, because they divorced with their knowhow partner there, and their investment plans got such a big dent that their showcase-raised equity funds of 360 million Euros are now waiting to be reconstructed

Recent successes of medium size systems

- Superior Fresh LLC is a fish farm and processing operation located in Hixton, Wisconsin. Focusing on commercial coldwater aquaponics, Superior Fresh LLC raises rainbow trout and Atlantic salmon in RAS in conjunction with a hydroponic greenhouse. The facility started with operation in 2018.
- Blue Ridge (Henry County, Virginia), said to be the world's largest producer of indoor-raised tilapia, produces 2 million kg of the fish a year using RAS and ships between 5,000 and 10,000 kg of live tilapia each day.
- A new partnership between Norwegian aquaculture company Aquacon AS and the University of Maryland Baltimore County's Institute of Marine and Environmental Technology (IMET) will bring an entirely new industry to Maryland's Eastern Shore: land-based salmon farms, in which the operation is entirely inside a massive warehouse where fish are grown with virtually zero waste.

RAS Fish Production in EU

- More than 27.000 tons were produced in recirculation systems in 2018 in the EU.
- RAS systems are mostly used for freshwater species, with more than 95% of the production occurring in freshwater environment (the remaining 5% occurring in sea and brackish water).
- Denmark, Netherlands, Germany, France and Poland are the leading MS, with more than 90% of the RAS production in the EU.
- In terms of species, rainbow trout, North African catfish and European eel accounted for 93% of the RAS production in the EU in 2018. Rainbow trout alone represented circa 62% of the EU production

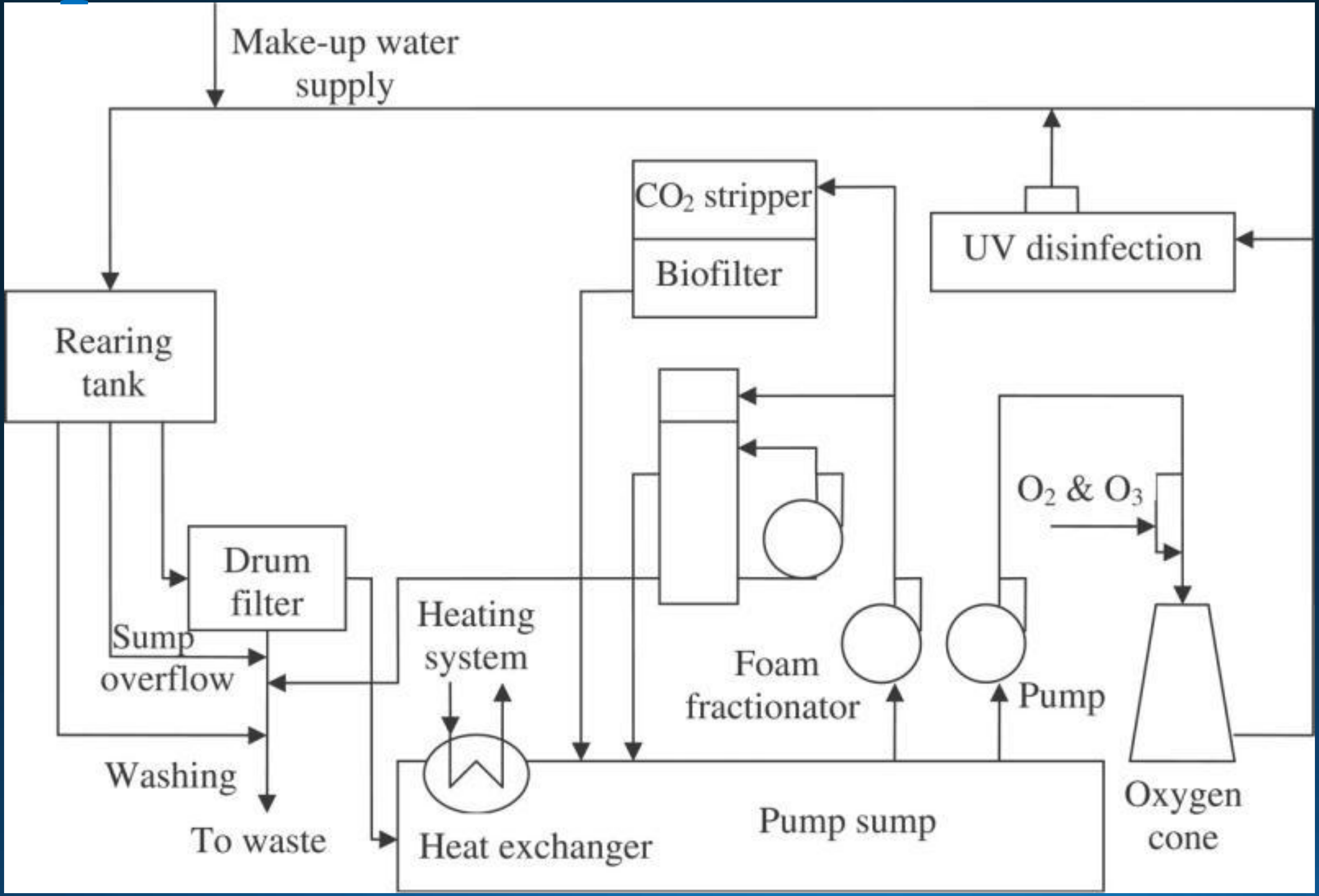


Simplified Process Flow Diagram for Recirculating Aquaculture Systems (RAS)
Make-up water
1 Grow-Out Tank
These are the large culture tanks where fish (or shellfish) are raised.
2 Solids Removal
Solids, such as fecal material and uneaten feeds are removed by mechanical filtration.
Recirculated Water "Out"
Fish Wastes & Uneaten Feed
Water outlet ?
Recirculated Water "In"
3 Biofiltration (Ammonia Removal)
Beneficial bacteria consume ammonia, which, converted into nitrogen, is released harmlessly into the atmosphere.
4 Dissolved Gas Control (Oxygenation)
The final step, and the most crucial for the fish, is to reoxygenate the culture water as it returns to the grow-out tank. Pure oxygen is injected to the returning water. Carbon dioxide is also removed.

The successful design and management of a high-tech closed recirculating aquaculture system

- Merge various “unit processes” for the treatment and movement of water, and for the control of water quality during intensive fish growing regimes
- This processes include mechanical, electrical and biological components, which combine to provide for the continuous recirculation and reuse of the culture water
- Optimal water temperature and water quality should be maintained through the entire fish rearing period, providing a nurturing and stress-free environment, which enhances the health and growth of the cultured fish.
- The water that is being recycled should also be constantly filtered and sterilized.

Implementation of different components



Monitoring and control of relevant rearing factors in RAS

The sophistication and quality of a system depends on the efficiency of each individual component – a system is only as efficient as its weakest component.

Relevant factor	RAS Component
❑ Oxygen	➢ Aeration/oxygenation component
❑ Turbidity	➢ Mechanical filter
❑ Ammonia	➢ Aerobic biofilter
❑ Microorganisms	➢ UV, ozone
❑ pH	➢ pH control component
❑ CO_2	➢ Degassing component
❑ Nitrates	➢ Anaerobic biofilter

Centralization vs. decentralization

Centralized system

- Higher risk
- Complicated management
- Inefficient feed management
- Lower initial cost

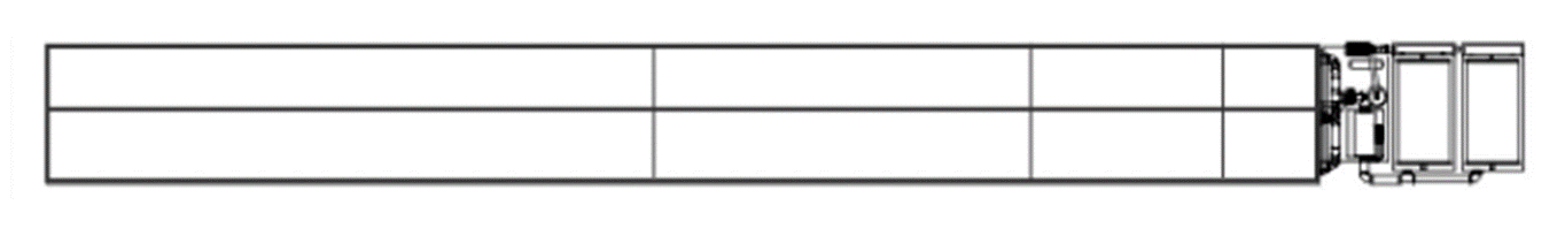
Individual treatment units

- Capital intensive
- Labor intensive
- Easier management
- Lower risk

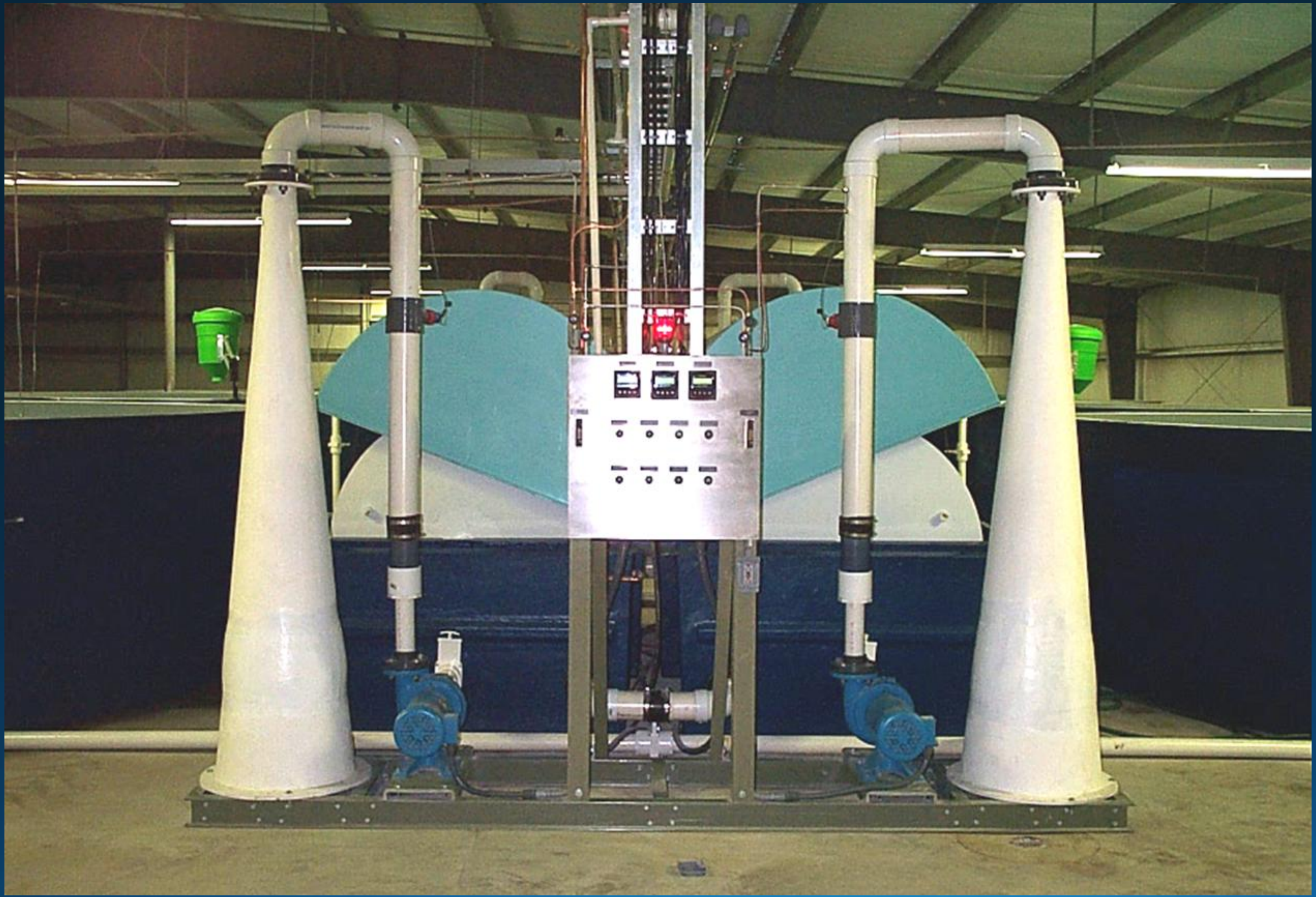
CENTRALIZED SYSTEM - one compact purification unit services multiple tanks, but with only one saturation column, so it is not possible to control the oxygen in each tank separately

OPERATIONAL PARAMETERS - STOCK MANAGEMENT

The maintenance of eight varying-sized system provides for extremely stable daily feeding levels, providing optimal and stable production levels.



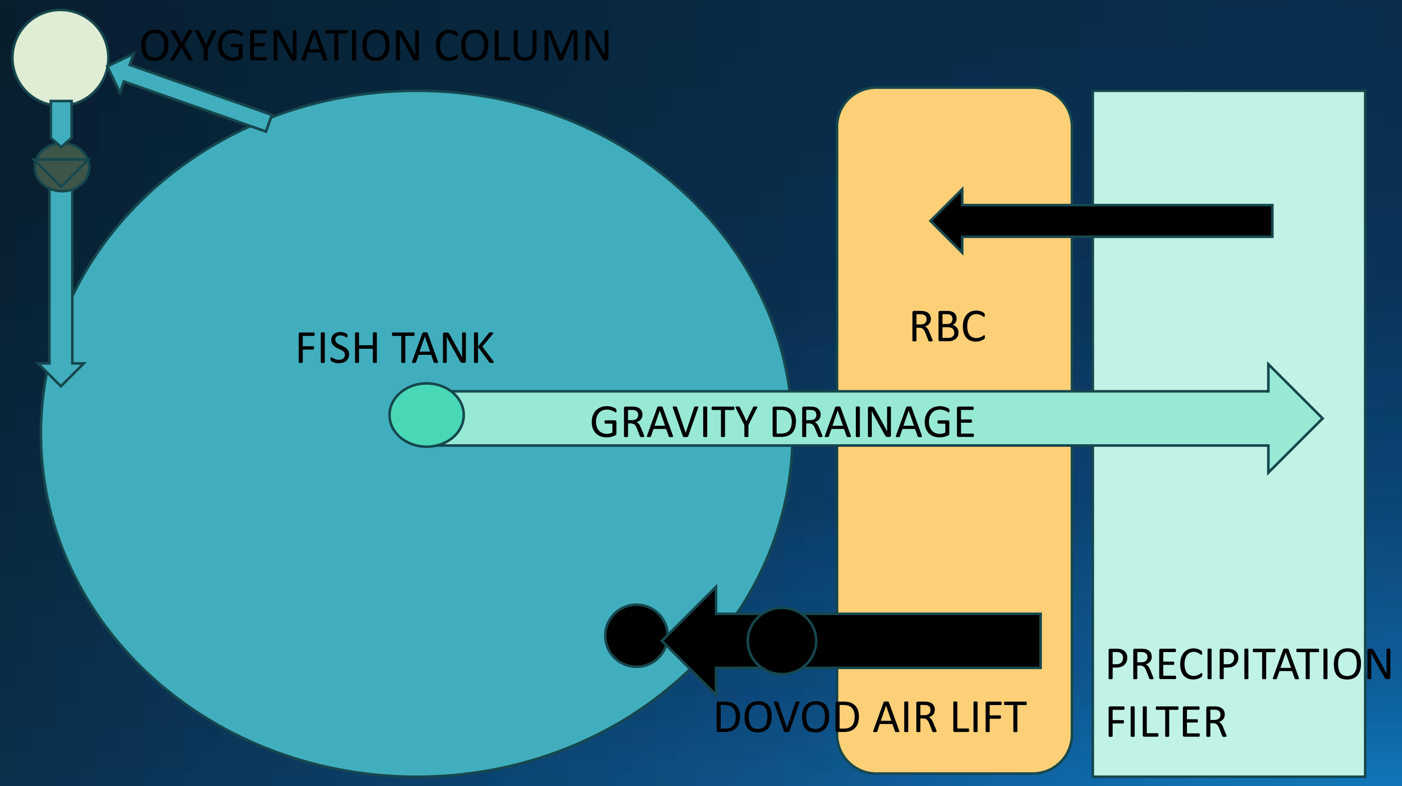
Custom designed sophisticated individual two-tank unit

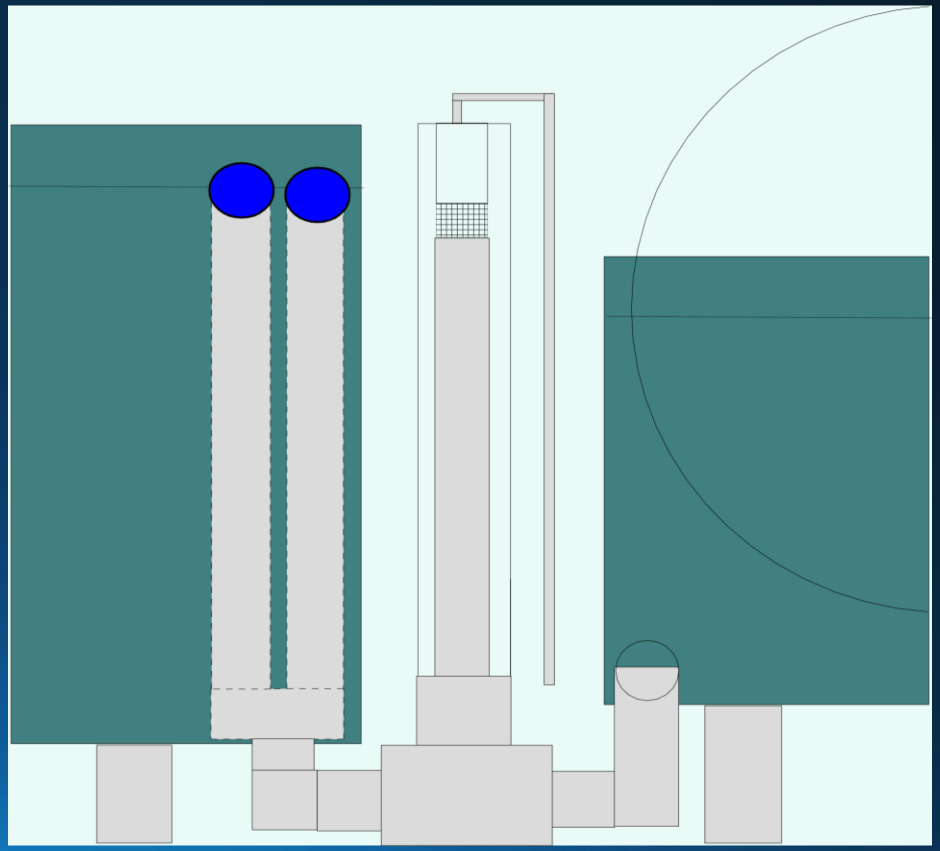


Low pressure single tank unit aquaculture system

Low pressure system diagram

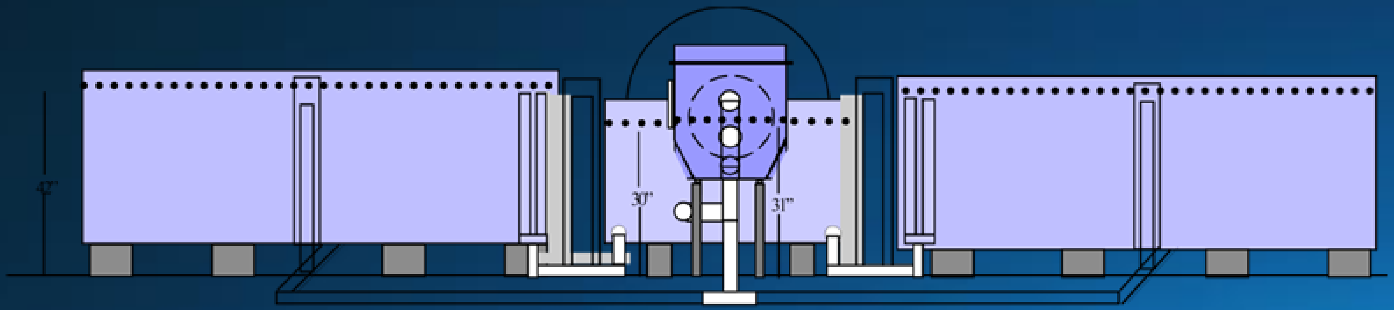
- Cheap unsophisticated equipment
- Requires a lot of relatively cheap human labor
- Very low energy costs

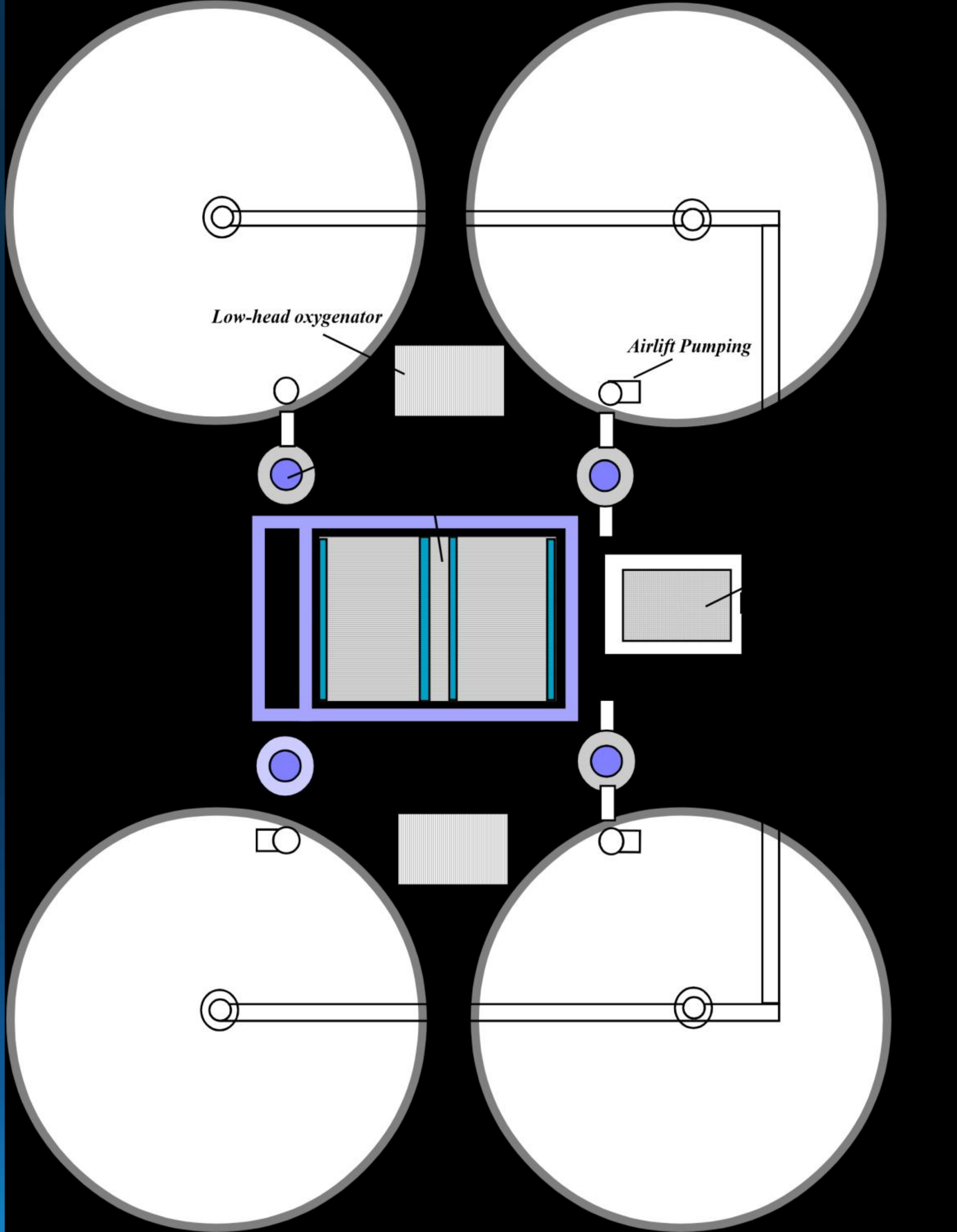




More sophisticated low-pressure system

- More sophisticated and efficient equipment
- Relatively high capital costs
- Low energy requirements
- Quite complicated management requires educated staff or sophisticated computer control

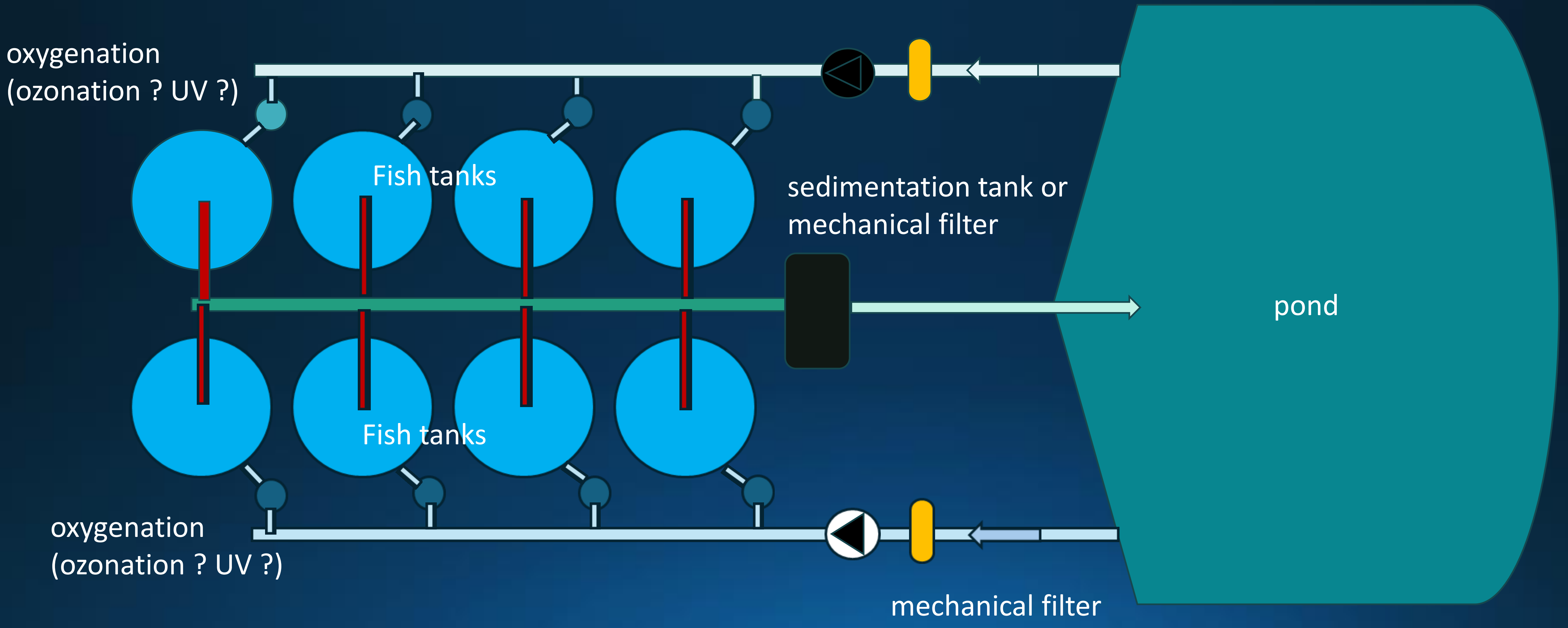




Aquaponic coupled system including RAS for tilapia farming and hydroponic system for lettuce production

- To be effective at nutrient removal, coupled aquaponics systems should be sized correctly to balance nutrient production from fish culture and nutrient uptake by plants. This balance can be tricky to achieve and maintain.
- Nitrification efficient at pH 7.5 or higher and practically ceases at less than 6.0. The optimum for nutrient solubility is 6.5. If pH is too high, nutrients precipitate out of solution and plants display nutrient deficiencies.

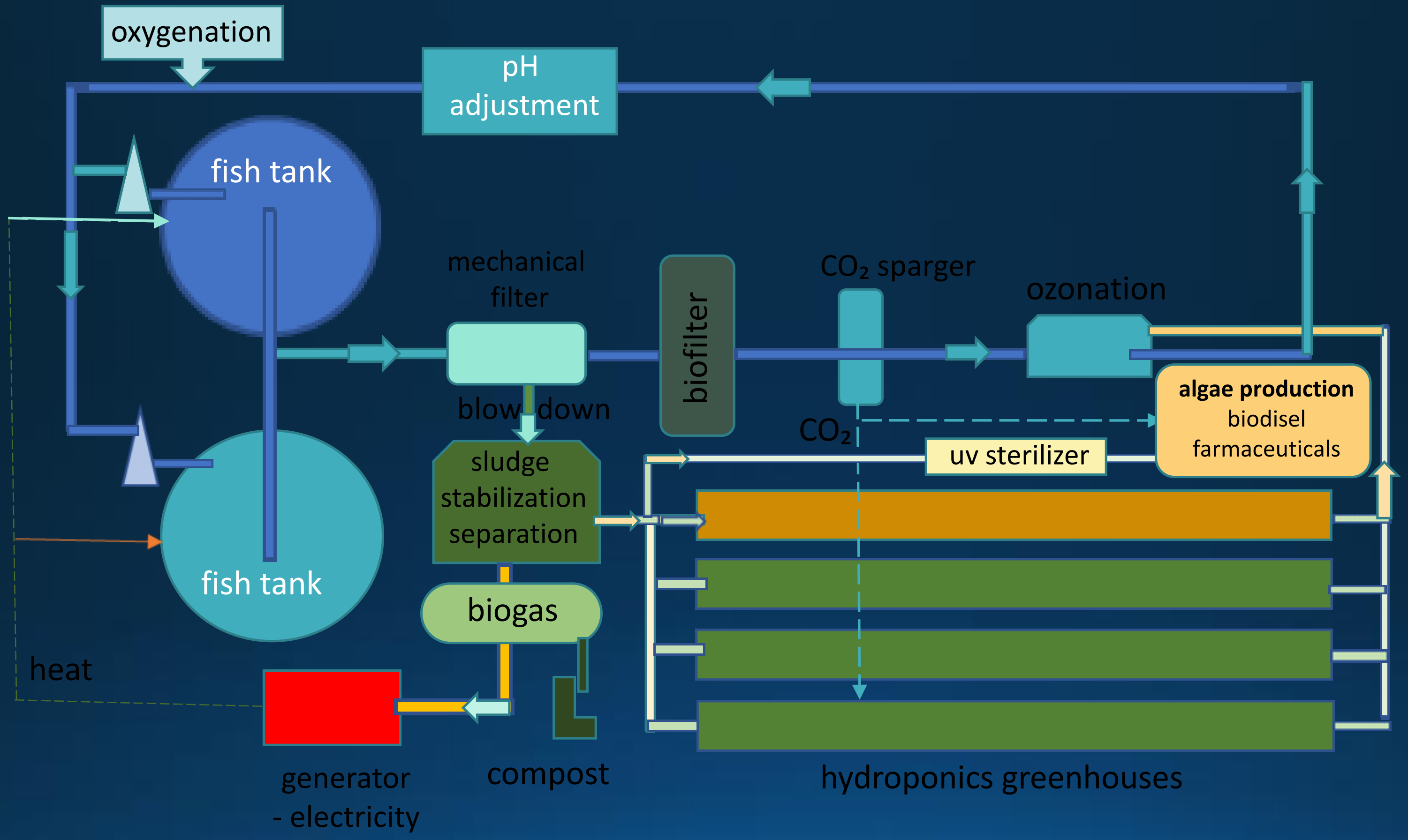
Natural (Pond) biofilter



Inclusion of RAS in Circular Economy

- A circular economy is an economic system aimed at eliminating waste and the continuous use of resources.
- It should minimize the use of resource inputs and the generation of waste and pollution and minimize carbon emissions. Circular economy would appear to be more sustainable than the current linear economic system.
- “Waste" should become "food" for another process: either a by-product or recovered resource for another industrial process or as regenerative resources for nature
- Circular systems employ reuse, sharing, repair, refurbishment, remanufacturing and recycling to create a closed-loop model

Inclusion of RAS in circular economy



CONCLUSSIONS

- Serious investment houses and institutions are getting into large closed recirculation fish production systems
- As real cost of culturing fish through traditional methods and legal challenges increases, custom designed RAS production systems will become economically acceptable aquaculture technologies
- Closed recirculating aquaculture systems integrated with hydroponic greenhouses and energy producing systems, will become one of the most environmentally acceptable and economically viable methods of sustainable food production.
- Such innovative agriculture system designs beside socioeconomic and environmental, could guarantee also energy sustainability creating a real circular process