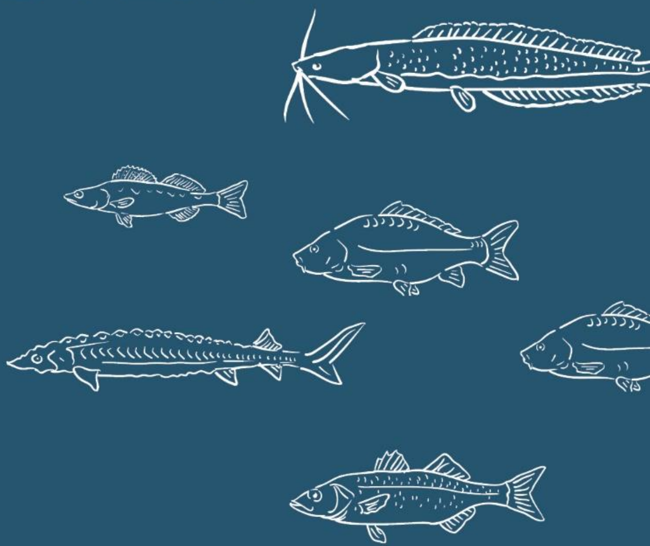
TANK BY POND SYSTEM FOR INTENSIVE FARMING

AQUACULTURE IN PONDS



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CONTENT

FOREWORD

This comprehensive manual serves as guidelines for constructing, maintaining and operating the Tank By Pond System developed by the G2O Company. The system has been developed to enable intensive farming at a relatively low cost of construction and maintenance comparing to the output production it offers. Therefore, it can be categorized as an economic way of intensive fishfarming. The system allows for farming various species, such as carp, african catfish, pike perch and sturgeon, among many others.

The main purpose of this publication is to allow fish farmers all over the world to try and implement in their farms a new, pioneer approach to pond faming, especially in the areas where modern and costly systems, such as RAS, are not common and feasible to construct. The Tank by Pond system, similarly to RAS, is based on water recirculation and uses equipment to pump water and provide oxygen to the system. Each section of this manual describes different aspects of its construction and operation.

INTRODUCTION

Intensive farming in ponds has approached its maximum and further intensification has limited potential. In Slovenia, a production of 5-10 t/h was achieved in smaller ponds (without water refreshing, with aeration and the use of high-quality extruded feed); similar results were achieved in regions with similar climatic conditions. Further growth of aquaculture in ponds will not be based only on the construction of new ponds, due to limited land areas, limited water availability, economic inefficiency of cultivation on large areas, restrictions related to nature conservation and numerous other limiting factors. At the same time, ponds have great potential for the introduction of new technologies, which will enable intensification in synergy with ponds, without increased needs for natural resources. For the organic growth and development of the cultivation of pond species, it is essential to introduce new systems without excluding existing practices.

The Tank By Pond system (TBP, "tank by pond") was developed by the company G2O d.o.o. (Slovenia) in the period 2018-2024 and according to the principle of operation it is related to the »Pond in Pond« system. TBP enables super-intensive breeding of warm-water fish in a combination of tanks and ponds, which are synergistically connected into a whole. According to the mechanism of action and efficiency, TBP is a RAS (Recirculation Aquaculture System) in which the function of mechanical and biological filtration is taken over by the pond; at the same time, TBP is much more robust, simpler to build and easier to use, and thus more economically efficient (in CAPEX and OPEX) than RAS. In the company G2O d.o.o. we breed cyprinids (in ponds), trout (in RAS) and African catfish (in RAS); at the same time, we design super-intensive systems (primarily RAS) and have over 70 references in 7 countries; thus, the solutions applied in the TBP system derive from various technical solutions, which were not only acquired in carp ponds.

All information in the manual comes from practice and has not been scientifically evaluated. All data are indicative and refer to the results achieved at the own fish farm, and as such have an orientational role in understanding the potential and capacity of the TBP system. We believe that the experiences gained in Slovenia are applicable (with modifications) at the global level. It is also important to note that the described solutions represent only some of the many possibilities that can be applied in the "Pond in Pond" principle, and are offered as possible and tested solutions, which should not be seen as final or optimal.

CULTIVATION CAPACITY OF THE TBP SYSTEM

Practice has shown that TBP has a cultivation capacity of 30 t/ha/year, without regular water refreshing. There is no regular supply of fresh water at the ponds of the G2O company; in the summer months, evaporation losses are compensated exclusively by occasional rainfall. The breeding capacity refers to the sum of the fish grown in the tanks and the associated pond, in which yields in smaller ponds are limited to approximately 10 t/ha/year, while yields in concrete tanks (kg/m3) are not defined, because the density of plantations depends primarily on the intensity of aeration and/or oxygenation. Previous experience has shown that the density of plantations expressed in 30 kg/m3 the upper limit for economically optimized and rational cultivation in tanks, with the use of aeration. If oxygenation (enrichment of water with pure oxygen) is used, the density of plantations is 3 times higher, but in this case it is necessary to analyze the economic parameters first, in order to achieve economically justified cultivation.

The ratio of breeding capacities in tanks and ponds will depend primarily on the characteristics of the pond: ponds with a large surface area with extensive breeding will be able to load a smaller part of the total production in the pond itself (e.g. 1-2 t/ha/year), while the greater part of the production will be in concrete tanks; in smaller ponds with intensive production (5-10 t/ha/year) approximately 1/3 of cultivation will be realized in the pond and 2/3 in concrete tanks.

The often asked question is why the production of 30 t/ha is not achievable in the pond and it is in the TBP, although the water filtration (that is, the decomposition of organic matter) in both cases is linked exclusively to the pond. The answer comes down to maintaining oxygen concentration, as the main limiting factor. In the pond, the fish itself consumes less oxygen than the rest of the pond eco system, which is sometimes very difficult to maintain with aeration, especially in critical periods of the season. In tanks, oxygen consumption is reduced to the fish's need for oxygen, because the density of plantations is usually 30 times higher than that in a pond; the constant drainage of mechanical impurities and the absence of sludge (the bottom is concrete or plastic) exclude most of the other oxygen consumers that are present in the pond. Oxygen consumption by plankton does not show a large impact in tanks, and regular use of lime can further reduce the possible impact of the same. Furthermore, the mechanical impurity (which is constanlty removed from the tank) is retained in the sedimentation basin (swirl separator), and (if necessary) is discharged into the pond (as a fertilizer) or is removed from the system (it can be used as fertilizer for arable land and the like) - in this way, the load on the eco system of the pond is reduced in connection with the decomposition of organic matter and thus oxygen consumption.

BASIC OPERATING PRINCIPLES OF THE TBP SYSTEM

The breeding technology in the pond itself will not be discussed in the following text, although it is clear that the pond is an inseparable part of the TBP system and that it is necessary to pay maximum attention to the technical and technological measures in the pond, in order to maintain proper hygiene, which will enable adequate water quality also in the tanks.

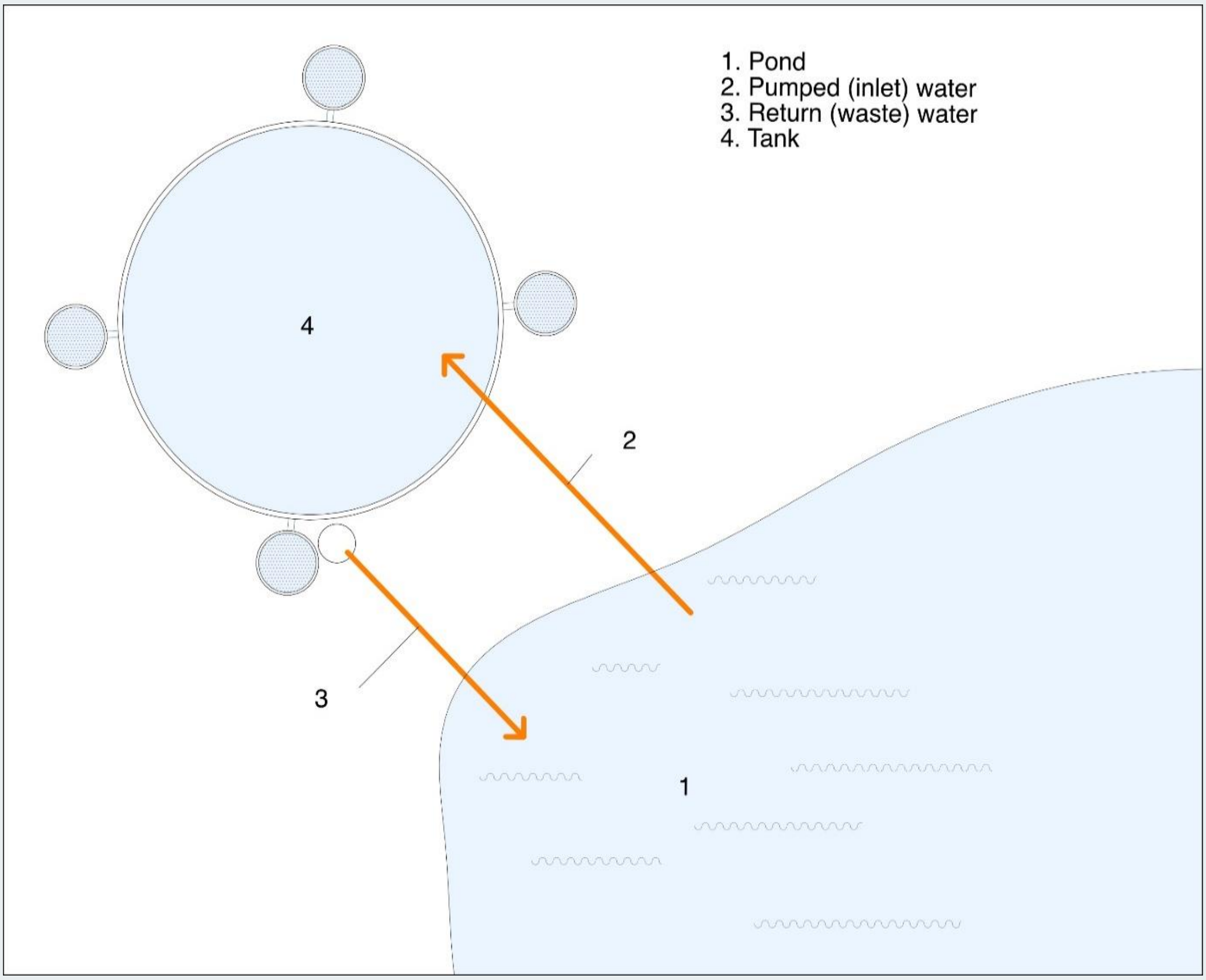


Fig. 1 Schematic drawing of TBP working principle

It is important to note that very extensive breeding (or the absence of breeding) in ponds is not recommended, because a certain amount of fish in a pond (lake, shoder pit, etc.) enables better water quality due to destratification, "processing" of benthos, utilization of plankton, etc. The organic matter that comes out of the concrete tanks into the pond is used by the eco system - the fish in the pond itself; in the case of too few plantations, there may be eutrophication of the pond and related problems for the breeding in the tank itself. An important benefit of the TBP system is the reduced FCR in the connected pond, due to the utilization of organic matter created in the pond, therefore neglecting cultivation in the pond reduces the economy of the overall production.

THE BASIC OPERATING PRINCIPLES OF THE TBP SYSTEM ARE BASED ON (EXCLUDING THE ALREADY MENTIONED FACTORS RELATED TO THE POND

- Correct design and measurements of the tank,
- Pumping (recirculation) of water,
- Aeration, oxygenation (optional),Sediment management,
- Monitoring and control of water quality.

3

TANKS – ROUND, DEEP AND LARGE

Tanks in the TBP system are round and can have different diameters. The diameter : depth ratio can be up to 3:1, which means that, for example, a tank with a diameter of 6 m can have an active depth (water column height) of up to 2 m, otherwise sediment removal will not be optimal because the proper flow of water in the tank will be disturbed. If fish that take food from the benthos (carp, sturgeon, catfish...) are grown, this ratio of diameter to depth is not very important and tanks with a higher than optimal water column do not show significant dysfunctions in sediment removal. Tanks with larger diameters can have a significantly greater active depth, although in practice tanks with a greater depth of approximately 3 m have proven to be demanding during construction and impractical when fishing, and the increased depth will not increase the yields quite proportionally. This especially applies to species that are not evenly distributed in the water column, such as carp, sturgeon, catfish. In practice, we use tanks of different diameters (5-40 m), and their dimensions will depend primarily on the planned species, planned quantities, breeding cycle, planned fishing rhythm, etc. As a rule, tanks with larger diameters are cheaper to build, calculating the expenditure per m3 of breeding volume of water, although in the case of tanks with large diameters, the functionality is somewhat impaired due to the proportionally large needs for aeration, which can hardly be met without the use of a large number of aerators, which represent a nuisance during fishing, and as a large number of devices require a lot of work during manipulation and servicing.

Fig. 2 TBP system with 15 m diameter tank (Fish farm Žabnik (Slovenia), G2O d.o.o.)

Based on past experience, tanks with dimensions of 15 m in diameter and 3 m in depth (hereinafter 15/3) have proven to be the "golden mean" because:

- the cost of construction per m3 of cultivation volume of water (CAPEX) is relatively low (acceptable),
- the quantity of farmed fish in an individual tank measuring 15 x 3 m justifies the investment in a stationary oxygen meter and automatic aeration,
- aeration can be achieved without the use of additional aerators, but only with airlifts, which facilitates fishing and minimizes maintenance.

Smaller tanks are also functionally acceptable, and are used when there is a need for several smaller tanks due to frequent sorting (e.g. perch breeding), simultaneous breeding of several different species, fingerling breeding, conducting experiments, etc. Tanks up to 20 m in diameter can still be aerated only with an airlift system, and larger tanks usually require aeration with aerators.

Fig.3 TBP system with 5 m diameter tanks (Fish farm Žabnik (Slovenia), G2O d.o.o.)

Tanks are made of concrete, and practice has shown that construction from concrete H blocks (hollow concrete blocks into which concrete is poured) is the fastest and most financially efficient technique. It is preferable that the tanks are buried in the ground and that the part above the ground is approximately 0.7 m. Tanks made of plastic or tarpaulin have a disadvantage because they cannot be buried in the ground in order to achieve a water column depth of 3 m, so they are usually shallower and part above the manipulation surface (terrain) is 1 m or more high, so manipulation during feeding, fishing and monitoring is difficult. The bottom of the tank is also concrete, and in the center there is an outlet (opening) protected by a mesh that prevents fish from escaping from the tank. In addition to the central outlet, it is preferable for the tank to have an outlet at the top of the water column, so that when the central opening is blocked (dead fish, leaves, etc.) the water can overflow over the upper overflow. The bottom of the tank does not have to have a slope towards the middle in order to achieve the "self-cleaning tank" effect, but a slope is desirable so that the fish concentrates towards the middle when fishing, which enables easier collection of fish during the final catch.

Fig. 4 TBP system during the construction.

The question is often asked why we don't use channels instead of round tanks. Channels require a completely different concept than TBP systems, which becomes clearer after the description of pumping (recirculation) and aeration, described in the following chapters. Channels have the only advantage - in the same channel, several different categories (types) of fish can be kept, because they can be separated from each other by nets. Catching fish can also be an advantage as fish can be concentrated with a movable baffle, which is not feasible in a round tank.

The advantage of dividing channels with nets in the "Pond in Pond" system is questionable, because the nets are regularly overgrown with algae and require regular cleaning and maintenance (unlike channels for breeding cold-water species), so this advantage is rarely used in practice. The biggest disadvantage of the channel is in the removal of sediment from the bottom of the tank (»self-cleaning«), which, compared to round tanks, requires at least 8 times more water flow. In the TBP system, the goal is not to maintain an adequate concentration of oxygen in the tank by pumping water from the pond, because the oxygen concentration in the pond fluctuates and can be very low in certain periods of the season. For this reason, pumping large amounts of water from the pond into the canals is most acceptable with airlifts (because they pump water and aerate the water at the same time), which operate only at small water height differences, which means that the canals must be at the water level in the pond and the water level in the the pond cannot not oscillate.

In our ponds, the water level drops by 50-70 cm in the season without regular rainfall, which means that in that period the canals would not be able to function with the airlift. The next disadvantage of the canals is the poor footprint utilization, because the canals, as a rule, cannot be deeper than 1-1.5 m, in order to satisfy the adequate flow (hydraulics) of the water that enables "self-cleaning" of the canals. In the literature, the good floor-plan utilization of the canal is emphasized many times, although this utilization in terms of water volume is significantly lower than round basins with larger diameters and thus greater depth. Also, the cost of building a canal is significantly higher than round basins, which is most easily demonstrated with the amount of construction material (m3 of concrete) required for the realization of a unit of water volume (m3 of water).

The IPRAS system developed in the USA uses channels, is very widespread and gives good breeding results, which often causes skepticism related to the superiority of round tanks in the TBP system. It is important to understand that the IPRAS system requires the construction (or reconstruction) of the entire pond in which a concrete partition (wall) is installed next to the concrete channels for fish farming, and the effectiveness of the system is equally dependent on the reconstruction (construction) of the pond as well as the channel. The size, dimensions and depth of the pond are precisely defined in relation to the breeding channels. The flow of water through the channels is made possible by maintaining the flow of water in the entire pond and only using an air pump in the channel is not enough to maintain the appropriate concentration of oxygen in the channel.

Furthermore, IPRAS was developed primarily for channel catfish, which tolerates high stocking densities and relatively lower oxygen concentrations than warm-water species typical for our region (carp, sturgeon, European catfish, perch, pike perch). The TBP system does not require pond reconstruction and can be applied to any pond with the same effect. This factor is especially important in our region, where carp are grown in ponds that are very old and their reconstruction is economically questionable and difficult to implement due to increasing restrictions related to the preservation of the natural environment of the ponds.

4 WATER PUMPING - RECIRCULATION

For the proper functioning of the TBP system, a constant flow of water into the breeding tank is required. The water can be pumped from the pond to which it is returned, or fresh water can be used that normally feeds the pond, with the fact that it first passes through the tank. If the pond has a constant flow of quality water, this water can be used on a larger scale for cultivation in tanks, in order to reduce the need for aeration; in that case, the system acts as a flow through fish farm with multiple (cascade) water use. If the pond does not have a constant inflow of quality water, water circulation between the pond and the tank is established with pumps. In this case, the inflow of water has the function of maintaining nitrogen compounds (TAN, nitrite nitrate) in satisfactory concentrations and enabling constant sediment drainage from the tank.

Fig. 5 Installed pump for supply of TBP system.

Practice has shown that the optimization of water pumping (recirculation) requires flexibility during the breeding season due to seasonal oscillations of oxygen concentration in the pond and the gradual increase of biomass in the tank and pond. At the beginning of the season, the concentration of oxygen in the pond is high and the concentration of fish in the tank and pond is low, so pumping water on a larger scale and without aeration often maintains optimal water parameters. Later in the season, the oxygen concentration in the pond will occasionally be low and it will be more loaded with organic substances (oxygen consumers), so it will be necessary to minimize water pumping and increase aeration. It is certainly desirable to equip larger tanks with stationary oxygen meters that will activate the aeration system as needed.

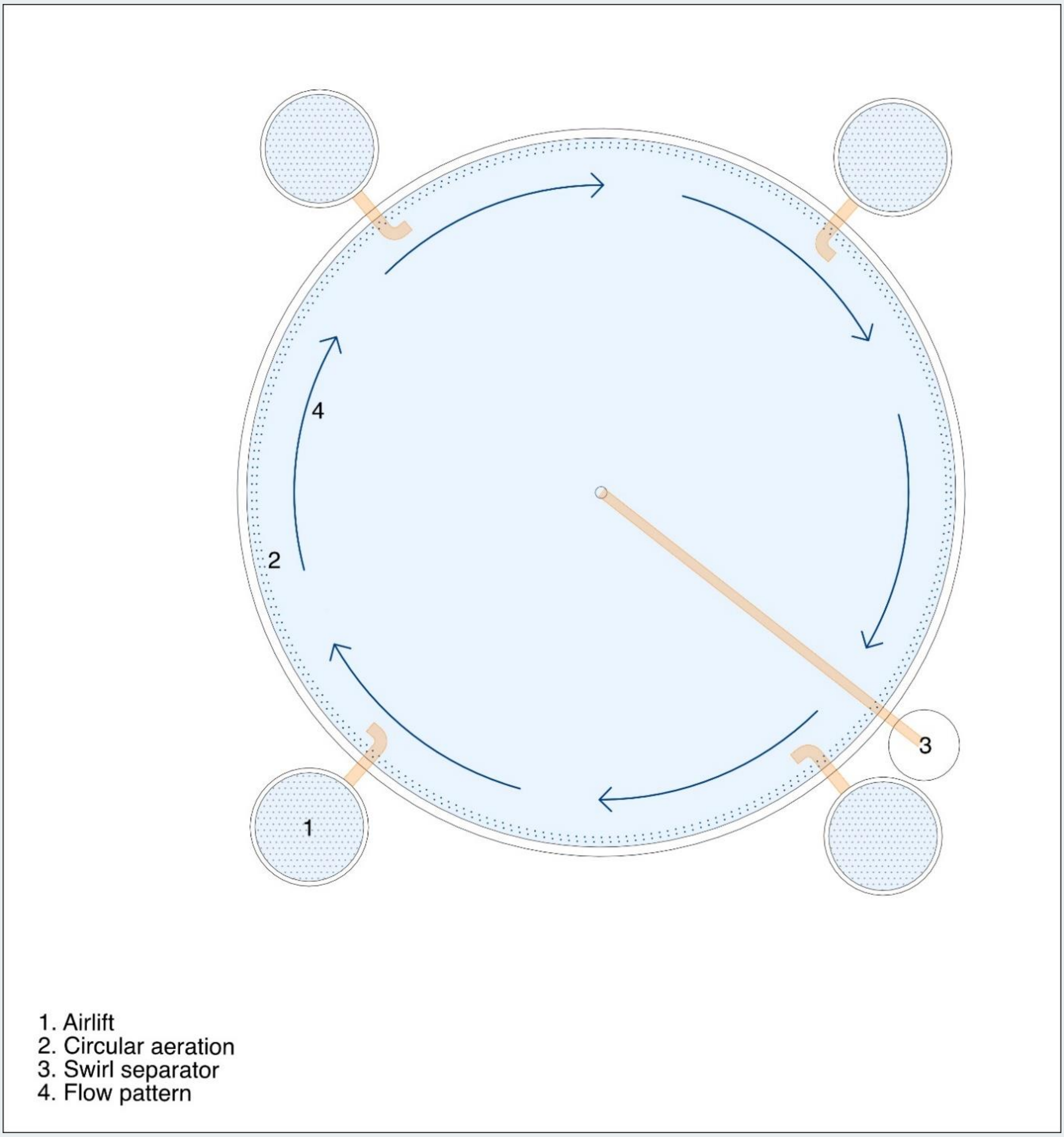


Fig. 6 Technical drawing of aeration and water velocity.

Roughly speaking, we can say that smaller tanks require a higher water change (20-30% change per hour) than larger tanks (40-100% change per day) in order to achieve the minimum flow required for self-cleaning, i.e. removing sediment from the tank. In a tank with a diameter of 15 m and a depth of 3 m, a water flow of 5 l/s is sufficient to enable self-cleaning of the tank, although even a flow half as low allows reflecting adequate concentrations of waste compounds, with the fact that in this case self-cleaning will not be satisfactory and it will be necessary to lower the level of water by 10-20 cm once a day, in order to remove the sediment from the center of the tank. Although the tank is not equipped with biological filters, the water from the pond carries numerous particles as carriers of microorganisms with a high nitrification potential, which, along with aeration in the tanks, enables intensive biological filtration equal to (or superior to) that in RAS.

As a general rule, we recommend that tanks be equipped with pumps that enable water exchange of 20-30% per hour with the possibility of flow regulation (several smaller pumps, frequency regulators), so that the flow can be optimized during the season.

5

AERATION

Aeration has the greatest importance in the TBP system because it simultaneously performs: maintenance of adequate oxygen concentration in water, circulation (flow) of water, destratification, degassing and biological filtration. Regarding the equipment, practice has shown that the use of radial two-stage blowers and membrane diffusers is the most common and most suitable choice. Radial two-stage blowers do not require regular service (practically no special maintenance), do not contain oil, are suitable for long air distributions (sometimes several hundreds of meters) and are effective even at higher pressure (higher water depth).

Fig. 6 Central installation of side channel blowers

Blowers are capacitated according to the general rule "as many m3 of water in the tank, as many m3 of air/hour". In addition to radial two-stage blowers, often choice are laso so-called "root" blowers and "high speed turbo" blowers. Root blowers require service (transmission oil change and belt replacement), while high speed turbo blowers offer significant savings in electricity consumption, but are relatively expensive, so adequate blower should be choosen based on energy efficiency, depreciation calculation and the need for maintenance. The blowers are usually installed centrally (for all concrete tanks and for ponds, if aeration is done in the ponds with air blowing), and distribution lines to all consumers are installed underground.

Fig. 7 Installation of side channel blowers for each airlift separately

The central installation of the blower reduces costs (primarily due to the reduced number of electrical cabinets and other electrical installations) and facilitates servicing and maintenance. If the tanks are equipped with stationary oxygen meters and automatic aeration, then each individual tank is equipped with its own blowers. As a rule, the blowers are equipped with frequency regulators that enable optimized power consumption and a soft start when switching on, which reduces peak loads.

In smaller tanks (up to approximately 5 m in diameter), aeration is performed using a tubular flexible diffuser (similar to a drip irrigation hose), which is mounted on the inner rim of the tank, approximately 1 m below the water level. Such an installation enables effective aeration, efficient water flow, and the installation itself does not interfere with fishing and other manipulations in the tank.

Fig. 8 Installed tubular (hose) diffuser

The tubular diffuser is usually placed in 2 circuits (double), in order to achieve a satisfactory air flow, because the tubular diffuser has a capacity of 1-2 m3/h/running meter of the diffuser, and it is necessary to calculate how many meters of the tubular diffuser are needed for a tank of a certain volume. This type of installation has the added advantage of reducing the viscosity (friction between the water and the wall) so that the directed flow of water more easily realizes the circular motion of the water. In addition to the circular movement of water, this type of aeration also achieves secondary circulation of water in the tank, which has proven to be very effective in sediment concentration in the center (siphon) of the tank and destratification. Sediment concentration in the center of the tank is key to the "self-cleaning" effect of the tank, and destratification encourages the "dispersed" distribution of fish in the tank.

In tanks larger than 5 m in diameter, along with tubular diffusers, air pumps (airlift) are installed, which are located next to the tank (on the outer side of the wall) and communicate with two openings (connecting pipes) at the bottom of the tank and at the top of the tank. Air pumps are essentially compartments that house diffusers; by blowing air (in addition to aeration) a pumping effect is created, i.e. water enters at the bottom of the airlift from the breeding tank and exits at the top of the airlift into the breeding tank. A PVC elbow is placed on the outlet pipe, which directs the flow of water in a circular motion. Airlift compartments are usually made of concrete pipes of different diameters (1-2 m diameter). The diameter of the compartment for airlift (concrete pipes) must contain an appropriate number of diffusers, in order to meet the amount of blown air per unit of time. In practice, we use tube diffusers (plastic tubes with drilled holes) or membrane diffusers; we prefer membrane diffusers due to greater transfer of oxygen into the water, the impossibility of a blocked hole (which happens relatively often with tube diffusers) and simpler installation. The airlift compartment has the same depth as the breeding tank itself, but the diffusers are not installed at the bottom of the compartment, but 1.5-1.7 m below the water level.

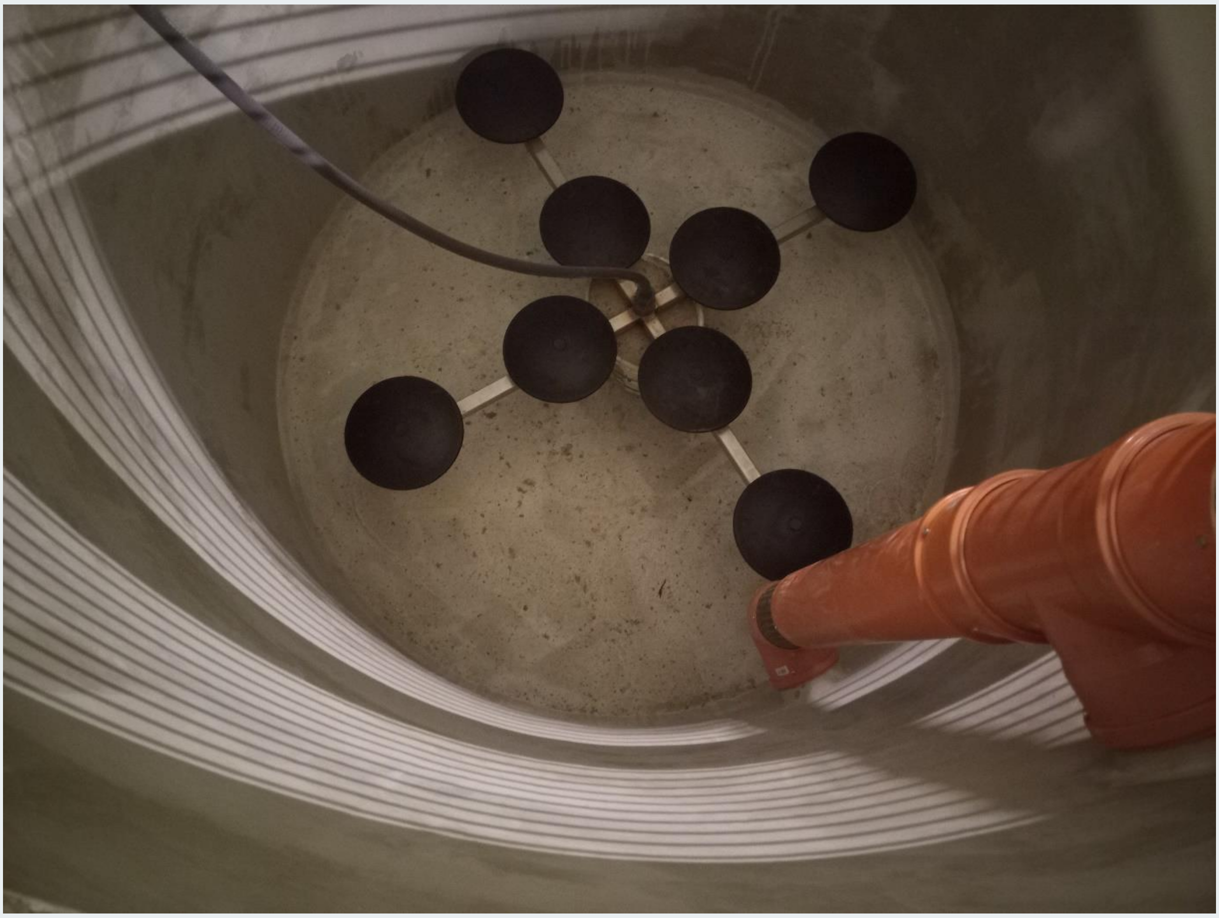


Fig. 9 Membrane disc diffusers installed in the airlift chamber

In this way, a good compromise was achieved between the enrichment of water with oxygen (the greater the depth of air blowing, the more effective the oxygen enrichment), and the amount of air blown (the amount of air blown is greater at lower depths), and the pumping effect (which increases with the depth). The amount of airlifts varies in relation to the diameter (volume) of the tank, usually 1-4 airlifts are installed per tank. For tanks with a diameter of 15 m and a depth of 3 m, we use 4 airlifts for each tank, which are made of concrete pipes with a diameter of 2 m, with openings of 300 mm, and in each airlift there are 8-12 membrane disk diffusers (the diameter of the individual diffuser is 300 mm).

Fig. 10 Coarse bubble diffuser (pipes with drilled holes) installed in the airlift chamber

In tanks larger than 20 m in diameter, it becomes more difficult to achieve aeration with only airlift systems located peripherally along the tank walls, and it is necessary to perform aeration in the tanks themselves, mostly with padlewheel aerators. Of course, there is the possibility of installing floating airlifts (with directed water flow) in the tank, which has certain advantages, because the system does not depend on many electric motors (aerators), but rather on central fans and air distribution. There is also the possibility of installing a centrally located airlift, which performs the secondary movement of water and the accumulation of sediment in the center of the tank, although this solution becomes less effective as the diameter of the tank increases. Hose diffusers are sometimes placed on the bottom of the tank, which can be placed in sufficient quantity to satisfy the aeration of large tanks, but they interfere with fishing and prevent the proper flow of water, necessary for self-cleaning of the tank.

Each tank is equipped with a settling tank (vortex or "swirl" separator), which is also a regulator of the height of the water level in the tank. The settling tank is a concrete pipe with a diameter of 1-1.5 m, the same height as the concrete tank, with a slightly lower bottom than the bottom of the tank. A pipe that connects the siphon enters the bottom of the clarifier and serves to drain water and sediment from the tank. At the top of the clarifier there is an overflow that allows the mechanically purified water to flow back into the pond, and the sediment is retained at the bottom of the clarifier. The overflow also serves as a water height regulator in the tank. At the bottom of the precipitator there is an opening closed by a vertical pipe, which is used to drain water from the tank, that is, it communicates with the drain pipe. It is preferable that the water discharge pipe is connected to a stream or a channel that is lower than the bottom of the tank, so that the tank can be emptied by free fall as needed, otherwise it is necessary to use a pump to empty the tank.

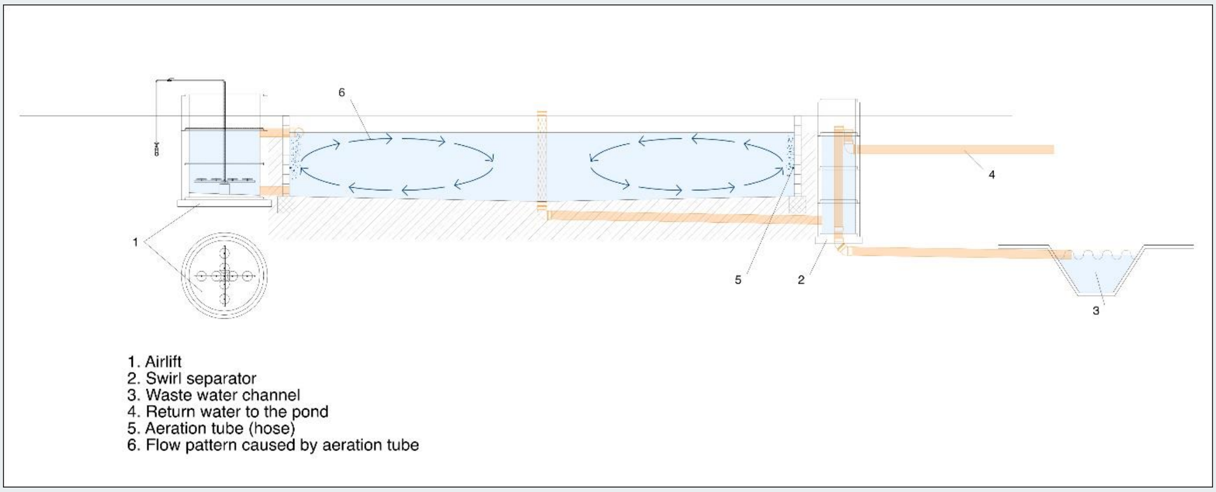


Fig. 11 Technical drawing of cross section and secondary water velocity

Accumulated sediment in the sedimentation tank can be periodically discharged into the pond, which is done by lowering the overflow height by approximately up to 0.5 m, which means that the water level in the tank must be at least 0.5 m higher than the water level in the pond. If the pond is overloaded with organic matter, the sediment can be pumped out and taken to agricultural areas or disposed of in another way, in accordance with the possibilities and legal regulations. During intensive feeding and high density of plantations, it is desirable to lower the water level in the concrete tank once a day, in order to remove the sediment around the siphon and thus further reduce the amount of sediment in the tank.

MONITORING AND WATER QUALITY CONTROL

The key parameter is oxygen, which as a rule of tumb must be above 4.0 mg/l (for carp). In smaller tanks, oxygen (and temperature) is measured at least twice a day, and the degree of aeration is adjusted with manual valves and adequate adjustment of the power of the central blowers. In larger tanks, a stationary oxygen meter is usually used, which activates the blower when the oxygen concentration falls below 4 mg/l. Sometimes, in larger tanks, the constant operation of the blower (centrally located for all fish farming needs) is applied, and the additional blower is switched on automatically via a stationary oxygen meter in the water, as needed ("fine tuning").

In practice, we do not measure other water parameters, and the main indicator of water quality is the appetite and behavior of the fish. In the case of excessive feeding and decomposition of uneaten food in the tanks (a typical mistake), there is a visible deterioration of the water quality, so it is necessary to stop the feeding, and additionally drain the water from the tank (that is, lower the water level in the tank) several times a day, until the quality of the water does not improve and the fish begin to show an increased appetite again. The measurement of other water parameters (TAN, NH2, NH3...) would certainly be useful, in order to be able to assess the organic load of the water and better regulate nutrition.

As a hygienic measure, hydrated lime is regularly used in a concentration of 10 g/m3 of water. The lime is placed in airlifts, which dissolve the lime and pump it into the tank. We did not use other biocides, because there was no need.

USE OF OXYGEN IN THE TBP SYSTEM

By using oxygen in the TBP system, as a rule, the density of plantations can be tripled (up to 90 kg/m3) compared to using only aeration (up to 30 kg/m3). The use of oxygen does not exclude aeration, which has a multiple role in the TBP system (water circulation, degassing, enrichment of water with oxygen, destratification, biological filtration). Although a high density of plantations can be maintained only with oxygenation, this is not economically justified, because the energy (and thus economic) efficiency of aeration ("SAE - Standard Aeration Efficiency") is significantly higher than oxygenation, i.e. for every kWh invested in aeration, we enrich it with water for approximately 2 kg of O2, while in oxygenation the oxygen dissolving is never 100%, i.e. for every kg of O2 used, we do not dissolve the same amount of O2. Furthermore, to efficiently dissolve oxygen in water, we have to spend energy, which further increases the difference between aeration and oxygenation. Hovewer, aeration is more effective with lower oxygen levels and it decrease toward 100 % saturation. From the above, it follows that with aeration we maintain the oxygen concentration to approximately 70% and the remaining 30% is achieved with oxygenation (figures are indicative).

Despite the clear calculation that oxygenation is energetically (economically) at least 3 times less efficient than oxygenation, oxygenation can have great potential in the TBP system in some cases:

- when the price of fish can bear the cost of oxygenation and there is an increased demand for fish,

- if it is cheaper to increase the yield per m3 of water by 3 times instead of building 3 times larger TBP system (if the construction cost is high, with long depreciation),

- when growing species that need high concentrations of oxygen (primarily perch),

- when high-value species are grown and the safety of the system is to be increased (sturgeon for caviar, queens, experimental fish, juveniles)

It is clear from the above that there is no excessive justification for the cultivation of carp and other species which are satisfied with an oxygen concentration of 4-5 mg/l (65-75 %) unless higher yields or greater safety are to be achieved; at the same time, oxygenation represents a great potential for a quick and efficient increase in yield and offers the possibility of diversification and quick response to market needs. If you want to take advantage of the maximum effect of oxygenation, supersaturation (melting oxygen over 100%) must be performed, usually over 300%. Supersaturated water is pumped into the tank to maintain an oxygen concentration of 90-100%. With a high plantation, an oxygen concentration of 65-75% will not be sufficient, because during feeding and other activities of the fish, this concentration drops very quickly by 20-30%, so care should be taken that the lower limit of the oxygen concentration is satisfactory, so as not to cause stress to the fish and in order for the feed conversion to be satisfactory. The most effective (practically without an equivalent alternative) way of dissolving oxygen is the use of the so-called U-tubes, which create high pressure (2-3 bar) without using high-pressure pumps, that is, without high energy consumption. The water that is pumped into the tank first passes through the U-tube; it is crucial to achieve a water flow speed in the U-tube of 1-3 m/s and a pressure of 0.4-0.6 bar, otherwise the oxygen bubbles traveling along the inner U-tube will form an air bubble that the pump will not be able to overcome (it will block flow).

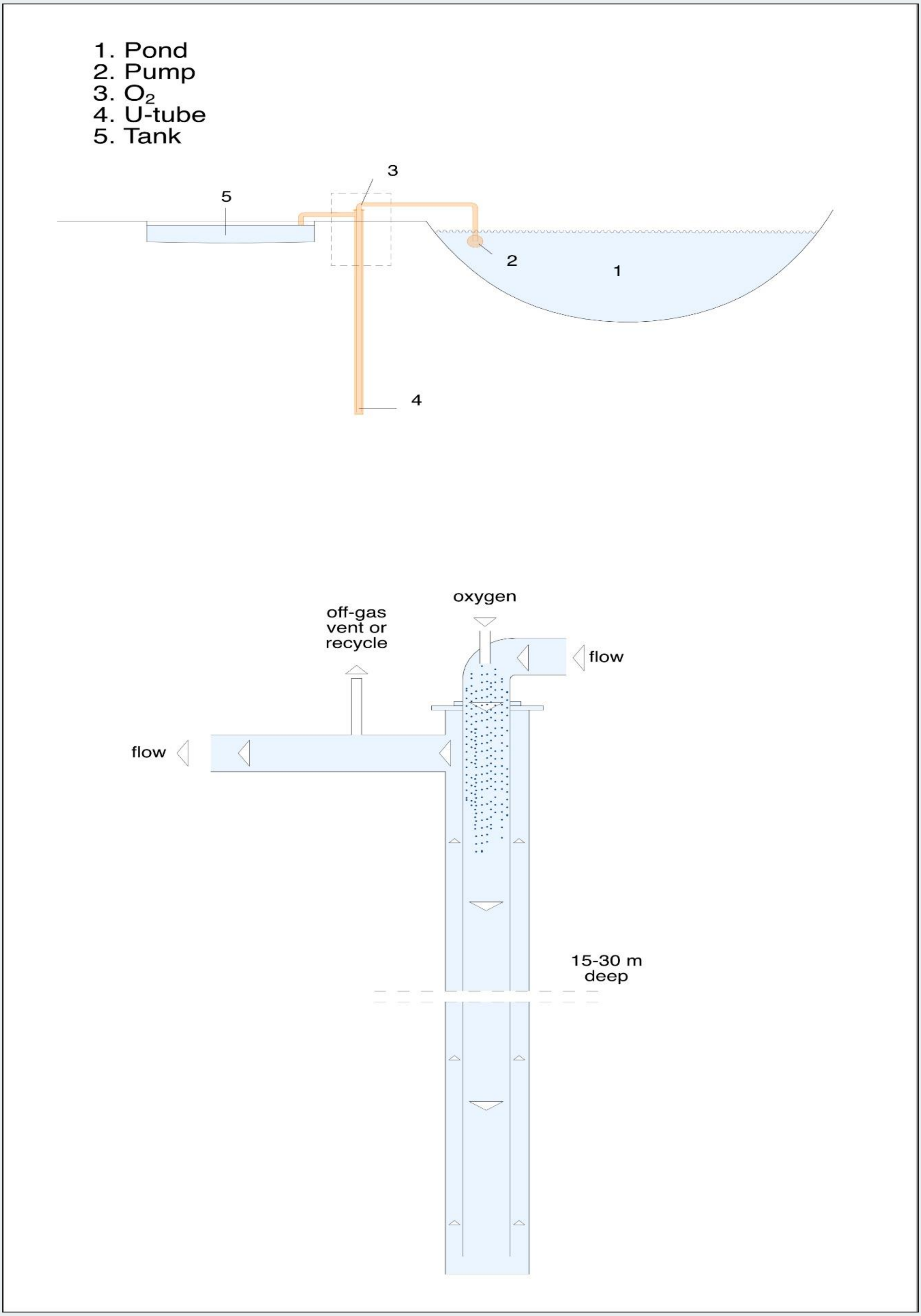


Fig. 11 shematic drawings of U-tube

In the case of oxygenation, the amount of daily oxygen intake must be calculated (framework calculation: 1 kg of O2 is needed for each kg of food), and the pump must be dimensioned according to the rule that the percentage of added oxygen to the water flow must not exceed 10% (otherwise the utilization/solubility of oxygen will decrease). It is important to emphasize that the efficiency of dissolving oxygen with U-tubes increases with the depth of the U-tube, which is optimally deep 20-40 m. It should be noted that in the case of using U-tubes, the so-called axial (propeller) pumps, despite the small height difference between the tank and the pond, are not suitable; centrifugal pumps with a slightly higher geodetic height (usually 5-10 m) will be needed. Likewise, the amount of water pumping will depend on the oxygen requirements and the water exchange will not normally be less than 25% of the tank volume per hour.

ECONOMIC ASPECT OF THE TBP SYSTEM

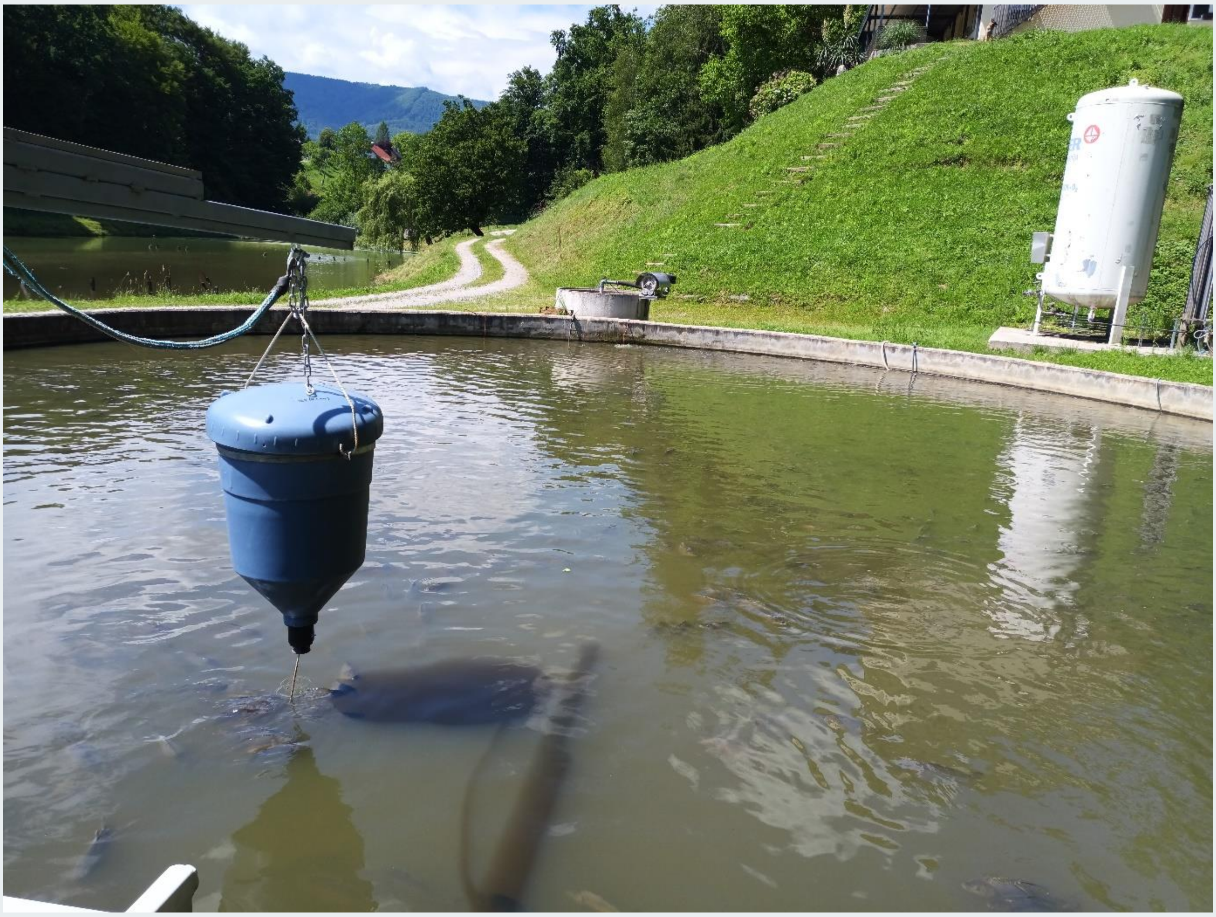
When considering the economic aspects of the TBP system, it is important to note that the goal of the TBP system is not to replace breeding in ponds, but rather to maximize the breeding potential of the ponds themselves. A TBP system without ponds will not realize its potential, just as the construction of new ponds (or reconstruction of existing ones) without a TBP system is not a sustainable path for numerous reasons (economic, ecological, high personnel demand, etc.). Existing ponds that have reached their maximum (approximately 10 t/ha/year) can increase their breeding capacity with the construction of new ponds and/or the construction of a TBP system. The capital investment in the construction of a TBP system (concrete tank with equipment) is generally lower than the investment in the construction of a new pond, although there are large differences at the regional level and globally in the cost of construction, land prices, legal regulations and other factors that affect the cost of the investment - so there are certainly exceptions. It is important to keep in mind that if the investor wants to triple the production in intensive pond farming, he must triple the cultivation area (and proportionally satisfy the demands for water) or build a TBP system (concrete basins) next to the existing pond, occupying a negligible area (less than 2% of the area belonging to the pond), without the need for additional water. A typical production tank 15/3 can be considered in terms of cultivation capacity (at least) as equivalent to a 1 ha pond, which is equipped for intensive cultivation (electrification, aerators, power generator, etc.). Practice has shown that the cost of building such a tank is relatively low and that it can be amortized in a period of 1-3 years.

Apart from the construction of the tank (or pond) itself, further maintenance costs are important, which are practically non-existent with the TBP system. In the case of ponds, silting, maintaining roads, mowing, repairing embankments (etc.) represent a significant cost and commitment, which is not productive. The maintenance and repairs of the TBP system equipment are not significant, do not require high expertise and do not differ significantly from the maintenance of aerators and pumps required for intensive cultivation in ponds. The cultivation cost in the TBP system is certainly an important parameter, if we arbitrarily accept that the investment in both systems is equal. Practice has shown that the energy consumption is approximately 2.5-3.5 kWh/kg of farmed fish in the TBP system, while this parameter is usually somewhat lower in ponds (1.5-2.5 kWh/kg). The feed conversion (FCR) in younger categories is equal in both systems, while in larger categories of fish (e.g. carp 1.5-3 kg) the conversion is slightly higher in the TBP system. We achieved the best results with carp with a final weight of 0.7-1.5 kg, where the conversion is usually 1.4-1.5 (Aller Classic or Forte).

The breeding cost is closely related to the total increase of biomass in the breeding season, which is the highest in the younger ones and significantly decreases with bigger fish. Let's take for example the cultivation of one-year-old juveniles (in a tank 15/3), where we enter the growing season with an extremely low biomass (e.g. 150,000 pieces of fingerlings; 150 kg biomass; 0.3 kg/m3) and end with 15 t of one summer old fish (30 kg/m3), that is, by a hundredfold increase in biomass. We enter the growing season with little invested capital, at the beginning of the season electricity consumption will be very low (due to low initial biomass), growth will be high throughout the season and FCR will be relatively low. If we want to grow large table size carp (3-4 kg), we will probably start with a plantation of 1.5 t (5000 pieces of average biomass 300 g; 3 kg/m3), and with significant electricity consumption from the very beginning of the season, and with rather poor FCR towards the end of the season, to achieve a tenfold increase in biomass.

Within the economic aspect, we can also consider the effects of diversification, e.g. intensive breeding of sturgeon, perch, perch, etc. in concrete tanks, which can significantly improve the economic results of fish farming, which otherwise cannot be grown (on a significant scale) in pond conditions.

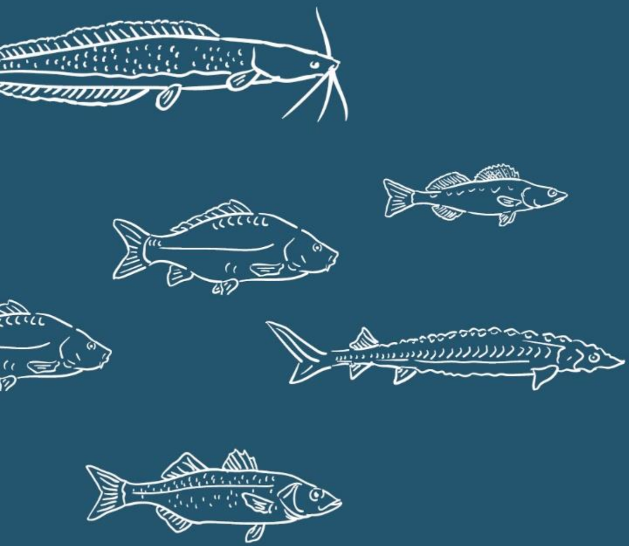
Indirect factors, such as: effective disease control, effective protection from predators and minimized influence of weather changes on water parameters, contribute to the economy of the TBP system. As a rule, head losses do not exceed 3%, which is incomparably lower than ponds (especially extensive ponds with a larger area). With the exception of viral diseases (which can cause the same consequences in a TBP system as in a pond), parasitic and conditional bacteriological diseases are simply controlled by regular baths; in most cases, regular use of hydrated lime (1-2 times a week) in a concentration of 10 g/m3 of water is the only measure that is performed. Protection against predators is very effective in concrete tanks; birds very rarely attack fish in concrete tanks. If necessary, concrete tanks can be covered with nets, which is economically efficient due to the small area and high productivity of the tank. Oxygen concentration in concrete tanks is constant, water parameters (TAN) do not oscillate; for this reason, stress for the fish is minimized and constant feeding is possible.



Picture: demand feeder in the 15/3 TBP system

Feeding with demand feeders maximise productivity and at the same time equalise water quality parameters during the day. On that way, fish takes feed whole day (also during the night), and it self-regulate feeding according to apatite, which is again related to environment. Our practice showed that 1 demand feeder is sufficient fort the 15/3 tank, because not all fish eat at the same time and there are no big oscillations in the growth among the stocking population in the tank.

LET'S GROW
TOGETHER



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