CHIP-Tuning in aquaculture (RAS)

CHIP-Tuning is the epitome of increase in efficiency.

The demand for efficiency improvement in recirculating aquaculture systems (RAS) is increasingly based on problems related to the water quality, process stability and/or insufficient nitrification performance.

Often, the reasons for the demand for tuning an RAS are of pure economical nature, for example in cases where the breeding animals cannot be sufficiently supplied with feed because otherwise the water quality might become unacceptable or even have a negative impact on the beings, or in cases where a significantly higher yield might be possible to generate whereas the RAS does not comply with the process requirements of the removal of higher nitrogen loads.

RAS plants are permanently subject to the usual fluctuations in the pollutant loads, which should normally be balanced by the system.

When the animals feel comfortable, the economy and ecology in your breeding system are in best order.

However; in many cases, an optimization of existing RAS plants and processes is not possible to be performed as insufficient pollutant removal rates might originate from too small reaction tank volumes. Hence, an expansion of the RAS plant would become necessary whereas this is not always easy to implement. This is similar to car tuning: increasing the performance of the car’s engine via increasing its cubic capacity is hardly to feasible; but it would be a much better way to perform a CHIP-tuning.

Deficiencies occurring in the biological treatment plants of existing recirculating aquaculture systems can be eliminated by means of optimal tuning with Mutag BioChip 25™ high-performance biofilm carriers. Alternatively, new RAS treatment plants can be brought to highest possible treatment performance. By performing a CHIP-tuning with Mutag BioChip 25™ biofilm carriers, the RAS operator benefits from larger fish populations, maximum fish feed quantities, constant treatment performance and process stability as well as optimal water quality, closer recirculation, new plants designed for maximum treatment capacity at small footprint, and so on. Hence, he benefits from the fact that the Mutag BioChip 25™ provides advantages which are significantly superior to those of “conventional” biofilm carriers.

In the following, it is explained how the Mutag BioChip 25™ carriers and its previous model are able to provide these advantages which they have now been showing in aquaculture for years.

The main task of the treatment stages in recirculating aquaculture systems (RAS) is the oxidation of ammonium by means of nitrification process which is to be understood as the bacterial oxidation of ammonium nitrogen (NH₄-N) in two steps via the oxidation of the latter first to nitrite (NO₂) and subsequently to nitrate (NO₃). For this purpose, the nitrifying microorganisms must be sufficiently provided with oxygen and other substrates. The maximum population size of the nitrifying bacteria depends however on the surface area available for the growth of microorganisms. Due to its fine pore structure and its protected active surface area of more than 4,000 m²/m³ which corresponds to the area of 11.5 tennis courts, the Mutag BioChip 25™ provides the optimal habitat conditions to the bacteria.

The Mutag BioChip 25™ carrier has a diameter of approx. 25 mm and a thickness of approx. 1,1 mm. Its surface shows a large number of closely spaced, open pores. These open pores and channels provide to the bacteria an optimal habitat at the surface area size mentioned above which accounts for a manyfold of the surface area size provided by “conventional” biofilm carriers. On the entire surface area, i.e. not only inside the pore system but also on the spaces between the pores, the bacteria can grow in the form of thin biofilms.
Due to the shear forces occurring on the mutual contact of the chip-shaped carrier media in the moving bed bioreactor (MBBR), the surfaces of the single carrier elements clean each other without any mechanical abrasion effects and allow for the growth of permanently thin and biologically active biofilms whereas all layers of these biofilms are completely accessible to oxygen and substrates.

![Fig. 1: Mutag BioChip 25™ carrier media (>4,000 m²/m³), virgin PE without any plasticizers](image1)

![Fig. 2: Pore system at magnification (zoom factor 40)](image2)

![Fig. 3: Cross section through the pore system colonized by biologically active biomass, material thickness approx. 1.1 mm](image3)

![Fig. 4: Scanning electron microscopic picture of the porous carrier surface, zoom factor 100](image4)

The Mutag BioChip 25™ has a very low tare weight related to the surface area provided, and can optimally be kept in suspension in the MBBR tank by means of low energy to be supplied. The slightly parabolic shape – comparable to the known potato crisps – promotes the carrier movement caused by process air supplied for oxygenation, and by the water turbulences in the tank. Due to the low tare weight in conjunction with the optimal and easy movement in the water, the kinetic energy occurring on the carrier media elements impacting the tank wall and/or other surfaces is remarkably low (negligible) and allows for an absolutely long lifetime. Larger and heavier carrier media types tend to increased abrasion and wear due to their higher kinetic energy.

Due to the low material thickness of approx. 1.1 mm, the biofilm on the Mutag BioChip 25™ surface is being optimally supplied from both sides with substrate and oxygen. Here, it has to be taken into account that the diffusion depth of substrate and oxygen is approx. 0.5 mm and both oxygen and substrate can diffuse into all layers of the biofilm from both sides of the chip-shaped carrier media. Compared to this, the optimal supply of biofilms on other carrier types with oxygen and substrate is not granted due to thicker biofilms and/or due to dead biofilms/biomass (clogging/siltation).

The actual CHIP-tuning for optimizing the biodegradation efficiency by a multiple of it is allowed for by the large surface area (>4,000 m²/m³) which is completely available for the growth of nitrifying bacteria. Compared to “conventional” carrier media, the removal rates were observed to be much more stable and constant, which can be ascribed to the optimal habitats as well as to the large surface area and its reserve capacities.
The target is it to activate a maximum of the population of biologically active bacteria in the smallest possible volume of the reaction tank(s).

Fig. 5: Mutag BioChip™ nitrification stage in the RAS of a sturgeon farm.

Fig. 6: Habitat “pore” of the Mutag BioChip™

Mutag BioChip™ carriers previously operated in a high-loaded nitrification stage were examined in terms of their content of aerobic ammonium-oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB). For this purpose, the moleculobiological VIT® gene probe technology was applied. As a result, a very stable population of AOB and NOB was identified.

Fig. 7: biofilm in a pore of the Mutag BioChip™

Fig. 8: ammonium-oxidizing bacteria (AOB) in a pore

Fig. 9: Nitrite-oxidizing bacteria (NOB) inside of a pore

Fig. 10: Both populations in one picture (AOB in red color and NOB in green color)
Within the new construction of recirculating aquaculture system treatment plants, the reactor volume can be reduced accordingly, or reserve capacities can be considered with regard to the high biodegradation performance of the Mutag BioChip 25™ carrier media.

For the period of approx. 5 years, the Mutag BioChip 25™ and its previous model, respectively, has not only been successfully tested in the breeding of sturgeon, catfish, bass, trout and koi, but it is also being used to great success by many fish breeders and process suppliers. The Mutag BioChip 25™ and its previous model is a product developed by Multi Umwelttechnologie AG based on the company’s decades-long experience in the application of “conventional” biofilm carriers in MBBR process, whereas Multi Umwelttechnologie AG is not only developer but also producer and distributor of the high-performance biofilm carrier. It is being supplied for utilization in biological water treatment systems in the aquaculture sector as well as for wastewater treatment in many industries and municipalities. The fields of application comprise but are not limited to COD/BOD removal, nitrification, de-nitrification, Anammox process up to the treatment of high-loaded nitrogen-containing, toxical coke oven effluents coming from the gas cleaning.

In the aquaculture sector, it is important to know that the Mutag BioChip 25™ is exclusively made of virgin PE material (no re-granulates from recycled material) and does not contain any plasticizers which might be ingested by the fish and finally end up on the plate for human consumption due to the food chain.

The material of the Mutag BioChip 25™ is very flexible, abrasion-resistant, and it does not break under pressure stress. Any unfoamed biofilm carriers with larger hollow spaces (small tube type, fan washer type, molded media) do not provide any suchlike buffer and, once exposed to pressure, they can get damaged very easily or get fine hairline cracks which may lead to complete fracture at a later point of time.

Multi Umwelttechnologie AG does not offer the supply of complete RAS plants but is able to provide assistance and constructional support in the design of MBBR tanks as well as of the related aeration and carrier media retention systems based on the decades-long experience gained in the field of MBBR technology. On request, Multi Umwelttechnologie AG can also provide process-related assistance during commissioning and normal operation.

Summary of major benefits

- Efficiency upgrade in existing systems
- Best water quality
- Closer or completely closed recirculation flows due to optimal biodegradation efficiency
- Energy savings in the treatment of feed water (tempering)
- Higher, constant process stability in case of fluctuations in the process conditions
- Smaller new construction plants or larger reserve capacities (reduction of reactor volume)
- Less transport volumes in shipment at similarly large surface area
- Long lifetime due to flexible, abrasion-resistant material
- Low mixing energy requirement in the MBBR tank
- Virgin PE (no recycled material) without any carcinogenic plasticizers
- Optimal supply of the microorganisms with substrate and oxygen due to thin biofilms
- Support in the designing or engineering of the aeration and carrier media retention systems
- Economical benefits in the price comparison per m² of protected active surface area

For more information, please visit [www.mutag.de](http://www.mutag.de) or kindly watch our multiple video clips which we uploaded on Youtube (key words: Mutag; Mutag BioChip).