HIGH WATER QUALITY

- IN RECIRCULATING AQUACULTURE SYSTEMS (RAS)

In the last few years, recirculating aquaculture systems (RAS) have further developed thanks to R&D, demonstration plants and the correspondingly derived fine-tuning, so fish can be produced in a competitive manner.

The success of a commercial fish farm is significantly depending on whether the fish can live in an environment with optimal water quality in order to grow faster and to stay healthy at the same time.

Although the "water" in a fish farm is a complex ecological system, the water quality can be checked by means of some parameters which play a crucial role. The critical parameters are the temperature, pH value, and the dissolved concentrations of oxygen, ammonium, nitrite, CO2, the alkalinity and the suspended solids. If the fresh water exchange is reduced, then the nitrate concentration might also reach critical levels which make it necessary to consider a reduction down to approx. 20 – 50 mg NO3-N/l.

Nitrogen is an essential nutrient for all living organisms. In aquaculture, nitrogen is a waste component, which is generated by the metabolism of the fish. There are different sources of nitrogen: ammonium, urea, uric acid and amino acids which are excreted by the fish, as well as organic residues of dead organisms, uneaten fish feed, feces, or gaseous nitrogen from the atmosphere.

Ammonium is generated as main end-product of the protein metabolism and is excreted by the fish via their gills mainly as non-ionized ammonium. Ammonium, nitrite and nitrate are well soluble in water.
Ammonium exists in two forms: non-ionized as NH3 and ionized as NH4 +. The relative concentration of both forms of the ammonium is primarily depending on the pH value, temperature and salt content.

The sum of both parameters (NH4 + + NH3) is called Total Ammonia Nitrogen (TAN). In chemistry, it is common to express inorganic nitrogen components in terms of the nitrogen which they contain: NH4 +-N (ionized ammonium nitrogen), NH3-N (non-ionized ammonium nitrogen), NO2-N (nitrite nitrogen), and NO3-N (nitrate nitrogen). This facilitates an easier calculation of the Total Ammonia Nitrogen (TAN = NH4 +-N + NH3-N) and an easier conversion between different stages of the nitrification process.

ADDITION OF FISH FEED = AMMONIA

As an end-product of their protein-metabolism, the fish are excreting via their gills mainly fish-toxic ammonia (NH3), which is present in the water as dissolved ammonium (NH4). Apart from this, a minor part of the nitrogen, particularly as urea, is excreted into the water via the kidneys.

In continuous-flow-systems, the fish tank water is massively diluted due to the high fresh water feed. Due to this, the NH3/NH4 concentration is kept at a level which is tolerable to the fish. This is however not possible in (partially) closed recirculating aquaculture systems due to the low fresh water quantity added to the system. Here, the ammonium in the recirculated water is oxidized by means of a special treatment stage: the biofilter. The application of a biofilter for the ammonium oxidation, in combination with the recirculation of the water back to the inlet of the fish tank, is the most essential attribute of (partially) closed recirculating systems.

The level of the NH3 concentration in the water is determined by the dissociation equilibrium between NH4 and NH3. At a rising pH value and increasing temperature, the percentage of the fish-toxic am- monia NH3 will rise. The NH3-N limit values of the optimal range at a longer working period are 0.008 mg NH3-N per liter (0.01 mg/l NH3) for trout and pikeperch, as well as 0.016 – 0.05 mg NH3-N per liter (0.02 – 0.06 mg/l NH3) for carp, eel, catfish and tilapia.

Moreover, in closed recirculating systems the concentrations of the intermediate and the end-product of the ammonium removal – nitrite and nitrate – are of significance. Within the scope of the accompa- nying water-chemical processes, also the pH value and the alkalinity (acid binding capacity) of the water are playing an essential role. For a range of fastidious fish species such as trout, sturgeon and pikeperch, it turned out that it is necessary to keep the NO3-N concentration below approx. 20 – 50 mg/l (approx. 90 – 220 mg/l NO3). Different species may also tolerate higher nitrate concentrations in some circumstances (approx. ≥ 300 mg/l NO3). The alkalinity should be at least at 1 mmol/l an the ph- value of the water between 6.5 – 7.5.

Only by re-using the fish tank water after its mechanical treatment and subsequent ammonium oxidation (biological treatment), it is possible to apply a fresh water feed which is lower than in the most intensely operated form of continuous-flow-systems.

In addition to the components required for growing the fish, as well as to the plant components and the carbon dioxide degassing unit, a closed recirculating system hence includes a mechanical treatment and a biofilter for the NH4-N oxidation

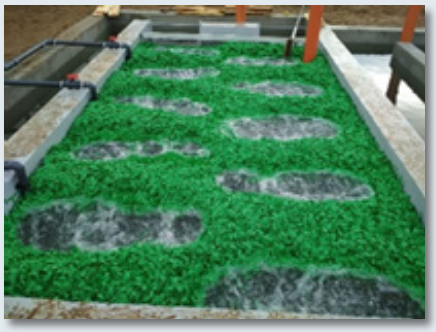
As process for the removal of the ammonium, nearly all commercially used recirculating systems are using the bacterial nitrification process. Here, the oxidation of the ammonium over the intermediate step nitrite (NO2) to the less fish-toxic nitrate (NO3) is performed by specialized bacteria species (Ni- trosomonas and Nitrobacter).

MUTAG BIOCHIP 30™ AS HIGH-PERFORMANCE CARRIER FOR RAS APPLICATIONS

Essential for the performance of the RAS is the choice of the carrier media on which the organisms for the biological treatment are supposed to grow in the MBBR tank (biofilter). During the past years, the Mutag BioChip 30™ with its extremely large and porous surface area - a product of Multi Um- welttechnologie AG - has been able to prevail in aquaculture on a world-wide basis. Several renowned suppliers of plants for fish farming are using the benefits of the Mutag BioChip 30™ for their systems which they sell to the aquaculture industry.

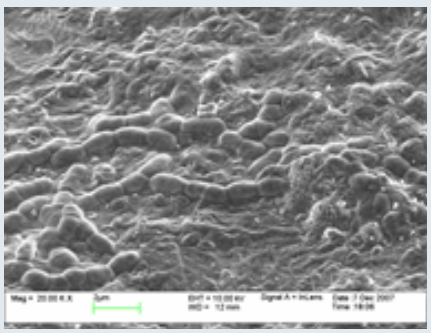
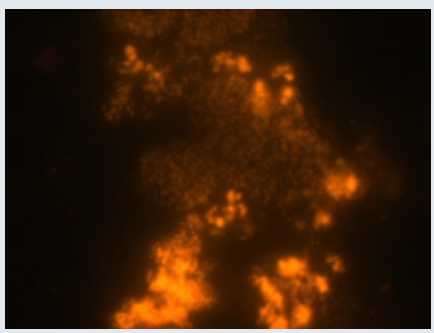
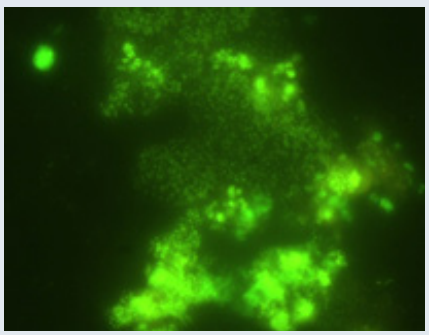
Apart from the high process reliability, further benefits are that the removal capacity is by a multiple higher than with other carriers, whereas the reactors (biofilters) are significantly smaller. Also the mix- ing energy requirement is lower; the latter is reduced particularly in relation to the tank footprint.





The photos show a MBBR system in a trout farm, together with carrier media retention system and aeration system during the start-up phase with Mutag BioChip 30™ carriers.

The microorganisms can excellently establish under optimal conditions on the large and porous surface of the MUTAG BioChip 30™ carrier media. The photos below show a typical biofilm of nitri- fying bacteria in microscopic images of NH4- and NO2- oxidizing bacteria on the surface of a Mutag BioChip 30™.

In the aquaculture sector, the standardized biological process combinations in the water treatment process comprise aerobic MBBR tanks for the removal of ammonium nitrogen (NH4-N) and COD (chemical oxygen demand) as well as MBBR denitrification tanks for the farther-reaching elimination of nitrate (NO3).

Besides the carrier media, Multi Umwelttechnologie AG offers also the design and engineering of the carrier media retention system, and provides process-related recom- mendations, support on commissioning, as well as cus- tomer service during operation. Any existing tanks can easily and quickly be optimized by using the Mutag MBBR Technology™.

THE MOST ESSENTIAL BENEFITS OF THE MUTAG BIOCHIP 30™ IN RAS APPLICATIONS IN BRIEF

- effective solution for capacity upgrade of existing plants and systems
- best water quality
- optimal performance for increasingly closed recycling systems
- energy savings in the feed water preparation process (temperature adjustment)
- higher, constant process reliability in case of process fluctuations
- smaller new constructions (savings in reactor volume) or higher reserve capacities for future in- creases in the production capacity
- lower shipping volumes of the carrier media at comparable surface area
- long lifetime thanks to flexible and abrasion-resistant material
- low mixing energy requirement in the biofilter (MBBR)
- optimal supply of the organisms with substrate and oxygen thanks to thin biofilms
- supplier's support on design or engineering of aeration and retention screens
- economical benefits per m of active surface area in price comparison

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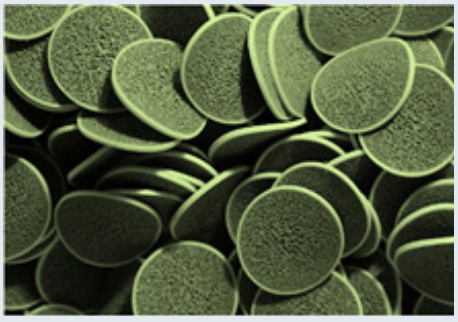
MUTAG BIOCHIP 30™ (VIRGIN PE)

- HIGH PERFORMANCE CARRIER MEDIA FOR BIOLOGICAL WATER TREATMENT

Essential benefits in summary:

- extremely high removal capacity due to maximized concentration of active biomass in small- est possible reaction volume
- clogging-resistant pore system thanks to self-cleaning effect caused by shear forces
- constant removal rates and high process reliability
- outer diameter approx. 30 mm
- suitable for the operation with blocking-resistant and large-perforated retention screens (per- foration Ø 20 mm)
- optimized motion behaviour in the moving bed
- free from abrasion and wear
- full diffusion of substrate and O2 into the complete biomass
- stable outer ring as protection against mechanical impacts
- THE carrier media of the future for most compact, high-performing biological water treatment systems, or for optimization of the removal capacity
- lower CAPEX due to lower carrier media requirement compared to conventional carrier media

MUTAG BioChip 30™



MUTAG BioChip 30™ colorized

Well-proven product thanks to more than 700 applications

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