Erwin Sander
Elektroapparatebau GmbH
Am Osterberg 22
31311 Uetze-Eltze, Germany
Tel. +49 5173 9710
Fax +49 5173 971197
www.aqua-sander.de

Ozone Information

by Dr. Jaime Orellana (V 6/26)

Ozone – The Power of Nature

Ozone is a special form of oxygen. Normally, two oxygen atoms combine to form an oxygen molecule. The ozone molecule, on the other hand, consists of a loose bond between three oxygen atoms. When this molecule breaks down, it seeks new reaction partners. All the effects that ozone has on biochemical reactions in the aquarium are based on its strong oxidising effect. Ozone is the strongest oxidising agent available for technical use. At the same time, it is environmentally friendly, as it consists of only three oxygen atoms and introduces no other chemicals into the aquarium water.

Applications in aquaria

Despite of a good filter system design, equipped with mechanical and biological filters, or protein skimmer in seawater, there are some situations in an aquarium where ozone can help us, such as:

- The occurrence of sudden peaks in nitrite levels
- The accumulation of substances that are difficult or impossible to break down biologically
- The occurrence of microbiological contamination of the water (increased bacterial count)
- Cloudy water or high turbidity
- The redox potential is too low

Ozone generation

As occurs naturally during a lightning strike, ozone is generated in the ozone electrode by spark discharge from the oxygen content of the air. The continuous flow of electrons transforms the oxygen molecule in the passing air into an ozone molecule.
The higher the voltage at the electrode, the higher the ozone content in the air flowing out of the ozoniser. Therefore, by adjusting the operating voltage of the ozoniser, the amount of ozone produced can be easily controlled. In the ozoniser, this is achieved using a variable resistor (potentiometer).
Unfortunately, it is not only oxygen that is converted into ozone in the ozoniser. The water vapour, which is always present in traces in the air, is also broken down to a small extent. In this process, it reacts with nitrogen. After prolonged operation, this reaction can cause nitric salts that will be deposited on the electrode surface. These lead to a significant reduction in the generation performance. The electrode should therefore be cleaned at regular intervals. As a rule, cleaning it approx. every 8 to 12 weeks should be enough.

Effect of ozone on the nitrogen cycle in the aquarium water

Ozone has a considerable influence on the nitrogen cycle. The particularly toxic nitrite stage is always oxidised by ozone to nitrate, and this reaction is pH-independent, meaning it occurs in seawater just as it does in freshwater. However, particularly when it comes to nitrite oxidation with ozone, it is important to remember that ozone is an aid in aquarium water treatment systems. Nitrite peaks can occur due to an animal that has died unnoticed, uncontrolled decomposition taking place in the substrate of the aquarium, or a biological filter that is not being supplied with enough oxygen and therefore cannot support the nitrifying bacteria in it. Biological filters often work well aerobically at first. The more organic they have filtered out, the more oxygen is consumed within the filter. The aerobic bacteria slowly die off, and the filter 'tips over'. The result can be an exceedingly high nitrite concentration in the aquarium water, as the filter is no longer breaking down nitrite but, on the contrary, releasing it. Regular filter cleaning is therefore recommended.

The effect of ozone on organic load

The overall level of organic pollution in the aquarium water can be expressed by the biochemical oxygen demand (BOD value), without going into detail about the individual related compounds. As mentioned above, substances accumulate in the aquarium that cannot be broken down by biological oxidation. These are primarily long-chain molecules, which are also responsible, within other things, for the unsightly yellow discolouration in the aquarium water. Whilst biological processes are unable to break down these substances, this is certainly possible with ozone. These yellowing substances are similar in their optical properties to the humic substances found in natural waters. They accumulate continuously in aquarium systems because they cannot be broken down by conventional filters. They originate mainly from fish feed and animal excretions. Yellow substances get their name from the fact that they give the water a yellowish colour. The removal of yellow substances using ozone has an aesthetic effect in addition to reducing the organic load. Yellow substances are used here merely as an example of substances that are not biodegradable and are therefore not captured or reflected by the BOD value. It is therefore especially important to consider not only the BOD but also the chemical oxygen demand (COD), which also accounts for substances that are difficult to degrade. As ozone oxidises long-chain molecules, the COD value initially falls slowly and then increasingly rapidly as oxidation progresses. However, oxidation does not proceed immediately to the final stage (CO_2), but intermediate stages in the form of shorter chains are first produced. These smaller compounds, however, are in turn biodegradable. This leads to the initially surprising effect that the BOD rises, as biologically non-degradable substances have been transformed by ozone in such a way that they can now be further broken down by biological processes. The result of this relationship is that oxidation with ozone does not need to be continued to the very end; in other words, only a relatively small amount of ozone is required to keep a healthy biological aquarium water over time.

Ozone and bacterial content in the aquarium water

An especially important property of ozone is its germicidal effect. Even when used in extremely low concentrations, ozone can influence microorganisms, particularly bacteria. In an aquarium, however, the purpose of using ozone cannot be to achieve sterile water. This would be intolerable for fish and other animals.

The relationship between ozone and redox potential

The redox potential is a measured value that provides information about the oxidation-reduction capacity of water. Reducing substances are oxygen-consuming substances. These include all organic substances, protein compounds, faeces, and food residues. These substances very quickly lead to toxic compounds such as ammonia and nitrite. Reducing substances cause the redox potential to drop, a sign of the deterioration of the aquarium water quality. Ozone therefore gives us the opportunity to counteract the negative effects of reducing substances by raising the redox potential.

Redox potential and disinfection level

When glass bottles are washed and sterilised with ozonated water, a redox potential of approx. 900 mV is aimed. In drinking water plants, a value of approx. 700 mV is targeted before the water goes to the household piping network. In an aquarium, a value of approx. 350 mV is entirely sufficient for a healthy and clean water. Scientific studies have shown that by raising the redox potential from 200 mV to 300 mV reduces the bacterial load by 90%. If a redox potential of approx. 400 mV is reached, approx. 1-5% of the initial bacterial load remains. If ozone dosing is to be operated continuously, automatic control of the ozone dosage via a redox potential measuring and control unit is recommended. This unit automatically adjusts the ozone dosage to the water load and prevents overdosing.

Ozone and animal welfare

Observations of *Labridae* animals kept at the Kiel Aquarium appear to confirm the effect of continuous low-level ozonation described above. A large number of wrasses brought in from Sweden exhibited both minor and more severe injuries resulting from capture, meaning that all the fish were expected to be highly susceptible to infection. During the animal rearing – the water was purified by the central ozonation and skimming system – it then became apparent that infections occurred only in the excessively severely injured animals. Although no chemicals or medication were used, the injuries healed within approximately 20 days. The ulceration of the wounds caused by infection also subsided, and the healing process proceeded successfully. Animals of this group were transferred to two aquariums that operated without ozone. There, the animals soon displayed the full clinical picture again, whilst the animals in Kiel healed completely. Fundamentally, the overall condition of the water and the animals is decisive for wound healing. However, ozone can, of course, significantly reduce the overall bacterial load in the water, thereby enabling the animals to activate their own immune defences.

Ozone in freshwater and seawater aquariums

In marine aquaria, ozone is a widely established method, whereas freshwater aquarists tend to be more cautious. It can be said, however, that ozone can essentially be used in freshwater in the same way as in marine water. All the properties of ozone, such as germicidal action, nitrite oxidation, removal of yellow substances, among others, can also be used in freshwater. Furthermore, the reaction of ozone, particularly in terms of speed, is pH-dependent. At high pH levels, ozone decomposes relatively quickly and is therefore forced to react very rapidly. At low pH levels, ozone remains stable for a relatively long time, meaning that the reaction occurs quite slowly. At low pH levels, the redox potential also rises significantly faster.

Using ozone correctly

It is generally recommended to introduce the ozone via a protein skimmer. Ozone is significantly more soluble than air. It can therefore be assumed that around 90 to 95% of the ozone remains in the water. The off gas of the protein skimmer will normally contain tiny amounts of rest ozone and therefore it must be treated with a so-called rest ozone decomposer.

Interaction between different filter systems

The key elements of water treatment in aquaria are mechanical and biological filtration, protein skimmer enhanced with ozone and UV.
The protein skimmer not only removes the organic load (particles and bacteria) but also enriches the water with oxygen. By providing a steady supply of oxygen, the skimmer creates an essential basis for a good biological filtration. Biological filtration, in turn, produces metabolic by-products which it releases into the water. These are primarily intermediate stages in mineralisation, i.e. the biological breakdown of organic matter into its mineral end products, such as phosphates, CO_2 and nitrogen compounds. The skimmer reabsorbs these metabolic by-products and removes them permanently from the water.

Effect of protein skimmers on the particle and bacteria content

The skimmer has a bacteria-harvesting effect. This can be explained by the fact that bacteria and other microorganisms tend to grow on the surface of particles dispersed in the water. When these particles are removed in the protein skimmer, microorganisms are also carried out of the water at the same time. We at Sander call this effect "mechanical disinfection".
The removal of particles produces clear water. Most animals are used to optically clear water in their natural environment. Particularly lower animals, algae, and aquatic plants are also dependent on being supplied with sufficient light for their survival. Clear water ensures that the light from the aquarium lamps also penetrates the deeper layers of the aquarium water.

Ozone and biological filtration

As shown in the chapter about ozone, certain organic compounds that are initially not biodegradable are pre-oxidised by ozone to such an extent that they can then be further broken down by a downstream biofilter. The scientific literature explains that there is also no risk of potentially inactivating the bacteria in the biofilter with ozone. Two factors are important here. Firstly, in aquarium technology, ozone is dosed in very small quantities. Secondly, the nitrifying bacteria are protected by growing within the biofilter substrate and being surrounded by an abundance of organic matter.