

What is eutrophication?

Eutrophication is the enrichment of nutrients such as phosphate (PO_4^{3-}) or nitrate (NO_3^-) in a water body. This stimulates algal growth and can result in a serious decline in water quality. For decades, eutrophication and associated risks to the biological community such as oxygen and biodiversity decline has been recognized as a serious issue globally. But there is still no uniform method for quantification of the trophic state.

What causes eutrophication?

Excess nutrients being released into coastal or estuarine systems originate from fertilizers and/or excess feedings used in agriculture and aquaculture. Since these natural waters can be the primary water source of aquaculture farms, insufficiently treated pond effluents and eutrophication means pollution of resources. Pollution and eutrophication have been increasing with the intensive growth of this sector.



Aquaculture ponds (left) and a wastewater channel of an aquaculture farm (right) at Hainan island, China

Consequences for organisms



A nutrient rich creek with intense algal blooms

As algal growth increases, less light reaches the bottom layer causing aquatic plants to die. Both, the dead plants and dying phytoplankton are consumed by microbes alongside with oxygen (O_2). O_2 is essential for the well-being of higher organisms such as fish. But, if O_2 declines seriously, a sufficient supply is not granted anymore. Mobile species migrate away from regimes of low O_2 (hypoxia) or are threatened to suffocate if they cannot. Anoxic (without O_2) conditions will cause all higher organisms to die. These regimes are therefore called dead zones.

Hypoxia and global warming

Microbes do not necessarily depend on O_2 . Under anoxic conditions they produce greenhouse gases (GHG) such as nitrous oxide (N_2O) and methane (CH_4) through anaerobic processes that keep them alive. These gases are partially released to the atmosphere where they can contribute to global warming.



Aquaculture in Hainan

Hainan island belongs to PR China and is a famous touristic hotspot. Hainan is also part of one of three major aquaculture zones. We screened the impact of aquaculture activity along its north-eastern coast for NO_3^- , PO_4^{3-} and O_2 contents and estimated the impact of eutrophication on oxygen in adjacent waters.

Monitoring GHGs

Microbial degradation of biomass and surplus food provided to the ponds can cause emissions of potent greenhouse gases (GHGs). With floating chamber experiments we measured CO_2 emissions from aquaculture ponds, their drainage channels and surrounding waters. We also monitored the concentrations of the major GHGs 24/7 over a period of about three weeks to estimate the contribution of aquaculture to global warming.



© M. Drews

Approaches to measure CO_2 emissions (left) using a floating chamber and to detect and record GHG concentrations in the pond water (right)

Does aquaculture mitigate CO_2 emissions?

During the permanent observation period, we found that phytoplankton absorbs CO_2 in the pond. CO_2 uptake mitigated nitrous oxide (N_2O) emissions. CH_4 has been constantly recorded at levels favoring emissions. These CH_4 emissions almost solely contributed to the net GHG emissions of the pond. Shrimp and cattle farming may therefore share similar issues. GHG production is subject to various environmental parameters that are affected by the management of the ponds. Improved operational strategies could help to minimize human GHG emissions.

Further interesting facts

- The largest dead zone in the Gulf of Mexico spanned over approx. 22,700 km^2 (2017). That is comparable to the size of New Jersey.
- Hypoxia and dead zones are increasing globally. Global warming supports this process as temperature increase stimulates microbial activity and decreases oxygen solubility.
- The warming potential of the GHGs CH_4 and N_2O exceeds that of CO_2 by approximately a factor of 30 and 300 respectively (IPCC 2013).

Interesting links

<https://oceanservice.noaa.gov/facts/eutrophication.html>
<http://www.fao.org/3/a-i7558e.pdf>
<https://www.youtube.com/watch?v=6LAT1gLMPu4>

<http://speakingofseafood.org/modules/seafood-in-the-global-protein-market/climate-impacts-seafood-capture-production-processing>