PROJECT:	WATERQUAL
SYSTEM:	RAS
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CtrlAQUA

H_2S risk in RAS

HYPOTHESIS:

- The ratio of biodegradable organic matter (BOD) to sulphate determines the total potential for H2S generation.
- The ratio of BOD to alternative electron acceptors determines net "release" potential for H2S.

DURATION: 2021-2022

SALINITY TESTED: Brackish water

HIGHLIGHTS:

- H_2S production potential of organic matter has been tested in continuously stirred batch reactors. H_2S production of sludge was tested with different nitrate levels (1% v/v sludge in 12 ppt brackish water; 0, 30, 60 and 120 mg/L NO3-N).
- Organic matter is preferentially used in denitrification. Nitrate delays and reduces H_2S response.
- Bioavailability of carbon is key to understand risks for H_2S: COD balance can be closed at ~100%, the fate of biodegradable matter can be predicted, and H_2S production potential calculated (Figure 1).
- The experiments confirmed that total and net H_2S production potential of organic matter can be calculated according to stoichiometric coefficients if COD degradability is known:
  - 2.86 g BOD/ g NO3-N (Metcalf & Eddy, 2004)
  - 2.67 g BOD / g S2- (Metcalf & Eddy, 2004)
  - Total H_2S production potential of organic matter can be calculated as: $S^{2-}[g] = COD[g] * uBOD/COD_{ratio} / 2.67$ (S2-/H_2S-ratio determined by pH: ~50% as H_2S at pH 7, ~10% at pH 8)

RECOMMENDATIONS:

- Reduce organic matter loading in RAS, especially feed spill: One kg of feed spilled has a 6 x higher potential for H2S production than the faecal waste produced from 1 kg of feed consumed (577 g S2-/kg feed vs. 90 g S2-/kg feed, respectively) (Figure 2).
- Avoid the build-up of organic matter (sediments, biofilms) in RAS, to reduce the potential for H2S production.
- Reduction of feed intake or increased water exchange can reduce nitrate concentration in RAS, potentially increasing the risk of H2S production.

PRACTICAL CONSIDERATIONS:

- The stoichiometric coefficients determined in batch tests do not quantify the net H_2S release potential from sediments or the "real" risk for brackish/marine RAS (no information of diffusion-limited systems, risk depends on rates of H_2S release & oxidation rates in sediment and system)
- Sludge properties determine the potential for H_2S production, but production kinetics in sediments will determine how this affects fish and system in RAS.
  - In sediments, diffusion will be the main rate-limiting factor for the uptake of nitrate and the release of H_2S.
  - A slow release of H_2S from sediments might not have an effect, if e.g. H_2S is oxidized in water or biofilter with O2 and/or NO3.
  - Total H_2S amounts can be estimated, but effect on fish system cannot be predicted without knowing pH and the dynamics of release and how this effect can cascade (e.g. potential feedback of stress/mortalities on oxygen availability in tanks).

READ MORE:

Højgaard, J. K. (2017). Mass mortality in RAS – Solved? SalmonBusiness. https://salmonbusiness.com/mass-mortality-in-ras-solved/

Tchobanoglous, G., Burton, F. L., Stensel, H. D., & Metcalf & Eddy Inc. (2004). Wastewater engineering: treatment and reuse (4th ed.). McGraw-Hill

Letelier-Gordo et al., 2020. https://**doi.**org/10.1016/j.aquaeng.2020.102062

The factsheet is not yet ready for implementation. More testing under commercial conditions is needed.

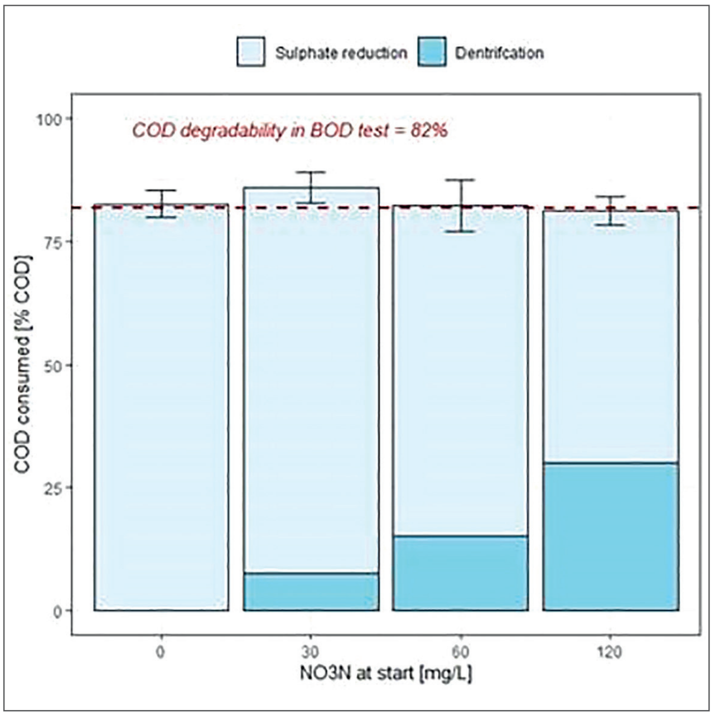
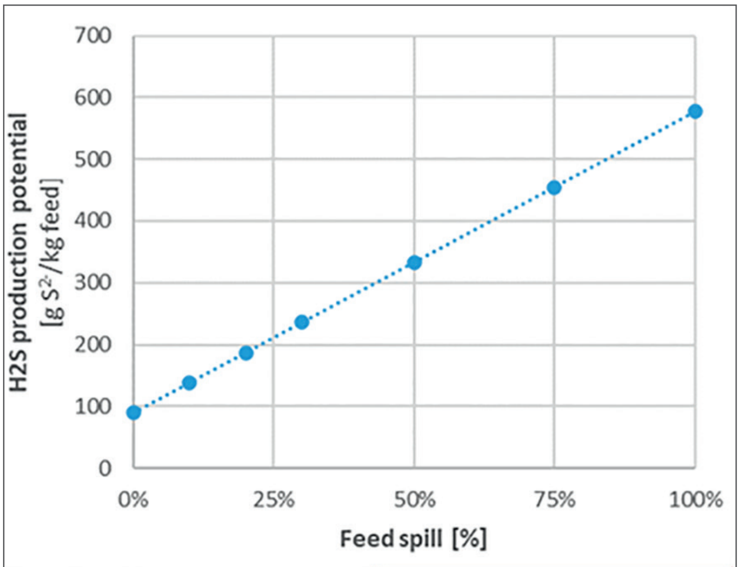


Figure 1: Allocation of biodegradable COD for the reduction of nitrate and sulphate in ideally-mixed batch reactors with sludge from Atlantic salmon (12 °C). The red line indicates COD degradability, determined in respirometric cBOD assays (uBOD, t = 41 d).



	COD [g/kg]	uBOD [g/kg feed]	S^{2-} [g/kg]
Feed DM	1600	1540	577
Feces DM	1200	960	360
Feces/kg feed eaten	300	240	90

Figure 2: Simple mass balance example to calculate effect of feed spill on total H_2S production potential. Results may vary based on diet, digestibility and carbon bioavailability; S^{2-}/$H2_S$-ratio determined by pH (~50% as H_2S at pH 7, ~10% at pH 8; depends on temperature).