ACTIVATED PARTICULATE ORGANIC MATTER AS A CARBON SOURCE FOR DENITRIFICATION IN RAS

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Sustainable aquaculture supplies fish products to market to meet the increasing need of fish and fish products in human diet and industry. Recirculating aquaculture systems (RAS), in which there is constant reuse of water, offer an extremely resource-efficient way to produce fish. Yet, RAS also need a constant water filtration in order to achieve adequate water parameters and finally quality products. Efforts to increase the effectiveness of the nitrification biofilters and denitrification reactors and to decrease the amount of solid waste in form of fish faeces and waste diet from a RAS are central research topics in this field. The present study aimed:

1) To analyze how efficiently fish use the inputs to the RAS system and the content of what is lost (e.g. in fish faeces, foam, waste diet etc) within waste products from a RAS,
2) To determine if filtered particulate organic matter, otherwise disposed of as waste, may be used as carbon source in a recycling procedure within RAS and,
3) To evaluate the effectiveness of ozone-activated particulate organic matter when used by denitrification bacteria as external carbon source.

An experiment was conducted in which individuals of European seabass *Dicentrarchus labrax,* kept in a RAS, were fed *ad libitum* with commercial feeds and the amount of solid waste (according to the feeds inputs) from the drum filter and the protein skimmer were determined, sampled before and after feeding and analyzed to examine their carbon, nitrogen and organic matter content (e.g. aminoacids, fatty acids) tested against the commercial feed used. Organic matter content was determined by gas chromatography and mass spectrometry. The sampled particulate organic matter from the drum filter was subsequently treated with ozone over various time intervals and its content analyzed to quantify simple carbon substrates feasible for use as carbon source by bacteria in the denitrification reactor. Ozone is commonly used for disinfection purpose and to clear the water from organic compounds responsible of the high turbidity of the water in RAS. It is as well toxic for living organism when higher levels leak to the system. The ozonized samples were tested against commercial carbon sources commonly used for RAS-denitrification at a laboratory scale with the aim of test it later on in a real system. The final objective is to evaluate the performance of denitrification reactors using ozone-activated particulate organic matter and to determine its influence on the growth performance of the studied species under these conditions as well as on the efficiency of the denitrification process. We expect to optimize RAS by recycling the particulate organic matter filtered out from the RAS and to find out the best ozone treatment time for obtaining an efficient denitrification and no collateral damage to the reared organisms or to the bacteria in denitrification reactors and nitrification biofilters. Preliminary results of this pilot study will be presented.

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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HELMHOLTZ ASSOCIATION

AWI-ACOMACS

- Aquaculture Research, Knowledge and Technology Transfer Group at AWI
- ACOMACS: Aims and reseach design
- Preliminary results

Technology Transfer:
From Research to Commercial Application

Aquaculture Research Group

Centre for Aquaculture Research (ZAF)

Main research focus:
RAS Technology

Pictures: Webpage AWI

AcOMaCS: Activated Particulate Organic Matter as Carbon Source for Denitrification

The AcOMaCS Project aims to improve the ecological and economic efficiency of RAS by recycling particulate wastes for use in denitrification.

Final product: Processing device for RAS sludge controlled by commonly used water parameters like pH/ORP and based on Ozone treatment

- **Partners within the project**
- AWI
- Ratz Aqua & Polymer Technik
- Hochschule Bremerhaven

Picture: D. Bögner

AcOMaCS: Activated Particulate Organic Matter as Carbon Source for Denitrification

Efficiency of inputs use in the RAS and content evaluation of waste sludge

Suitability of Ozone for treatment of particulate organic matter

Effectiveness of ozone-activated organic matter as Carbon source for denitrification

European seabass
Dicentrarchus labrax

Sludge rests and foam sampled for content analysis

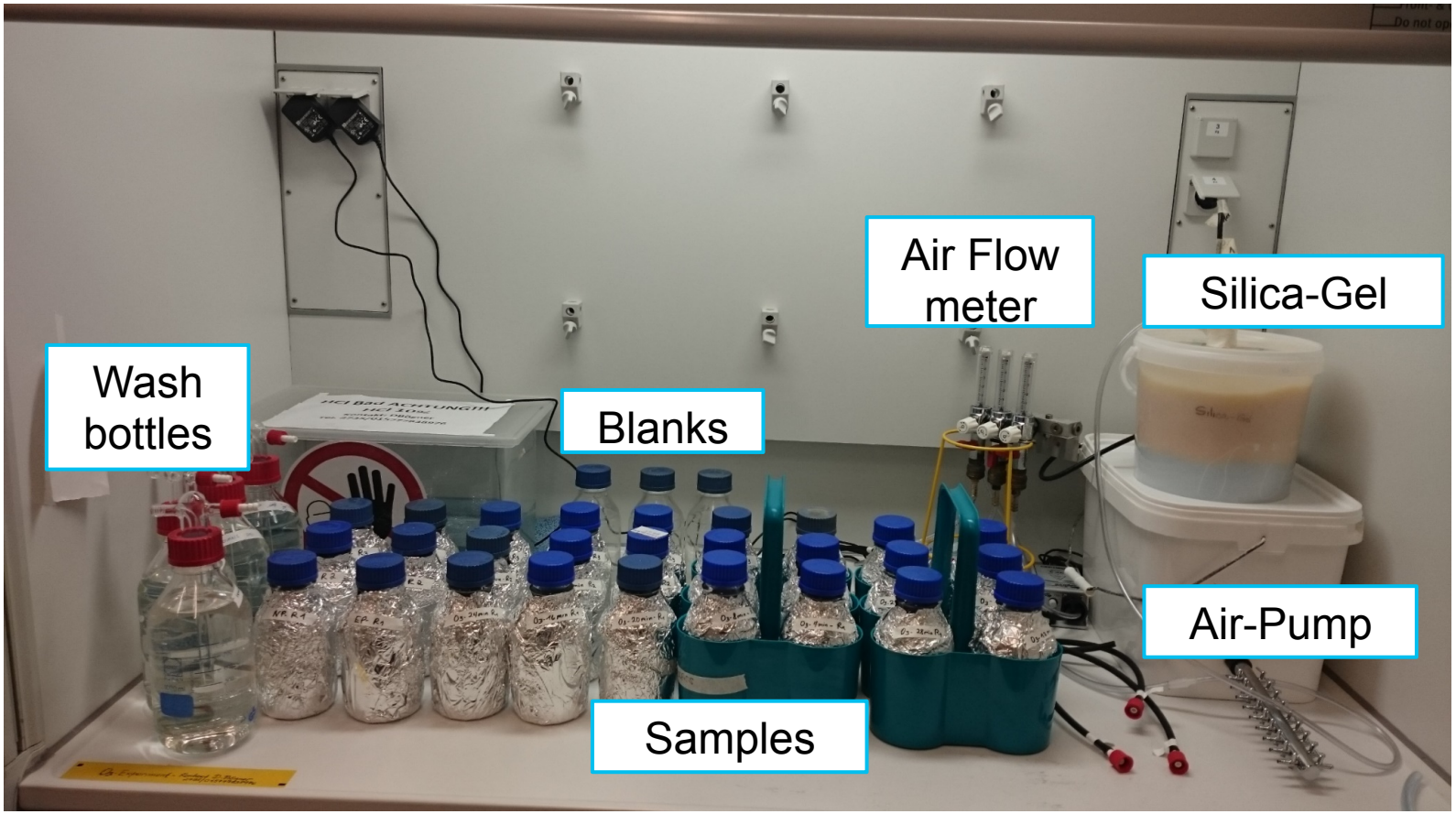
Sludge out of a collector installed to a RAS was used for ozonization experiments

Ozone-activated sludge is being tested as carbon source in mini-denitrification reactors (Lab-scale)

Pictures: M. and D. Bögner

AcOMaCS: Activated Particulate Organic Matter as Carbon Source for Denitrification

Ozonization experiments



Pictures: D. Bögner

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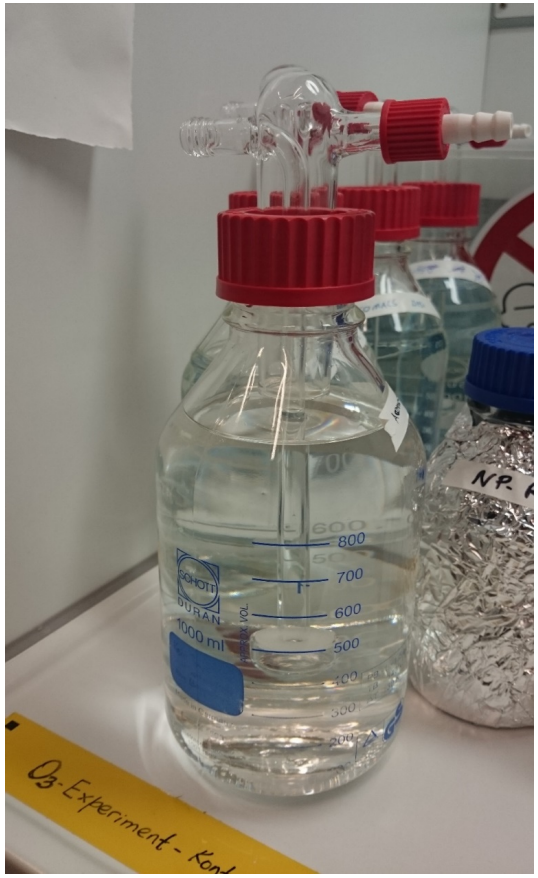
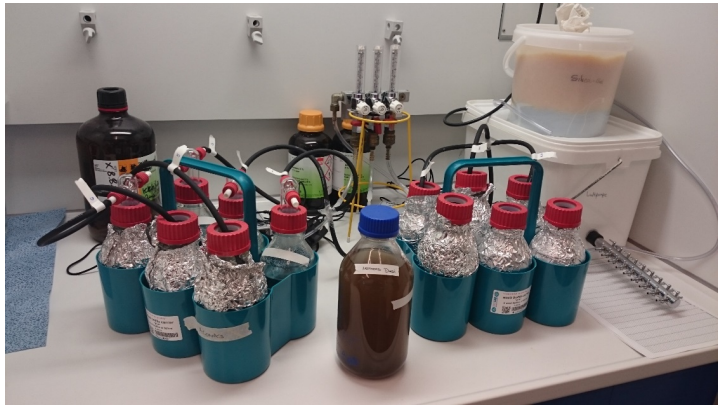
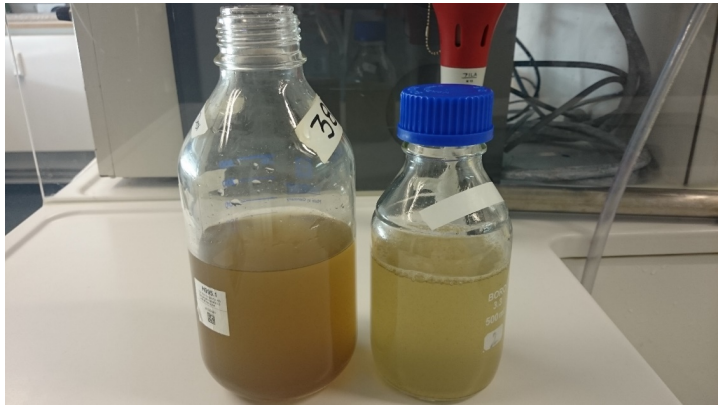
Ozonization experiments





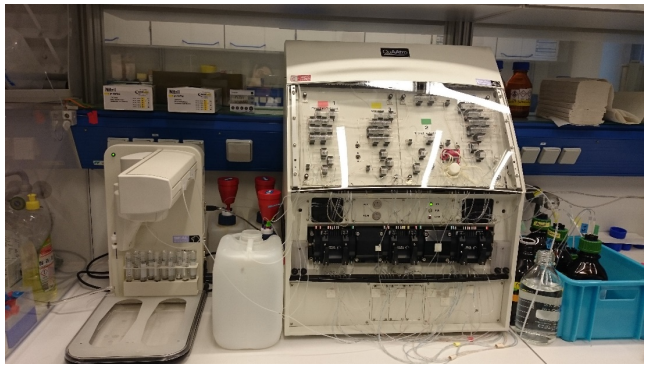


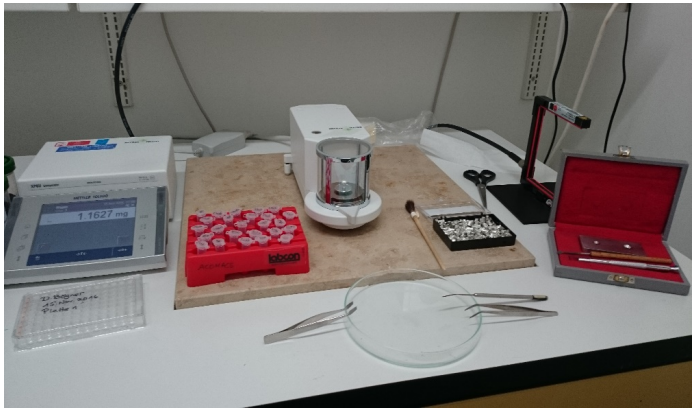
Pictures: D. Bögner

Water chemistry and C/N content in solid and liquid phases

Centrifugation and separation of solid and liquid phases

Ozone treatment 0-30 min





Pictures: D. Bögner

AcOMaCS: Activated Particulate Organic Matter as Carbon Source for Denitrification

Ozonization experiments

Denitrification:

$$NO_3^- \rightarrow NO_2^- \rightarrow NO + N_2O \rightarrow N_2$$

$$NH_4^+ + NO_2^- \rightarrow N_2 + 2\ H_2O\ (AnAmmOx)$$

Carbon source as electron donor e.g. acetic acid, methanol, acetol etc.

Theoretical optimal C:N ratio 3.74 for acetic acid

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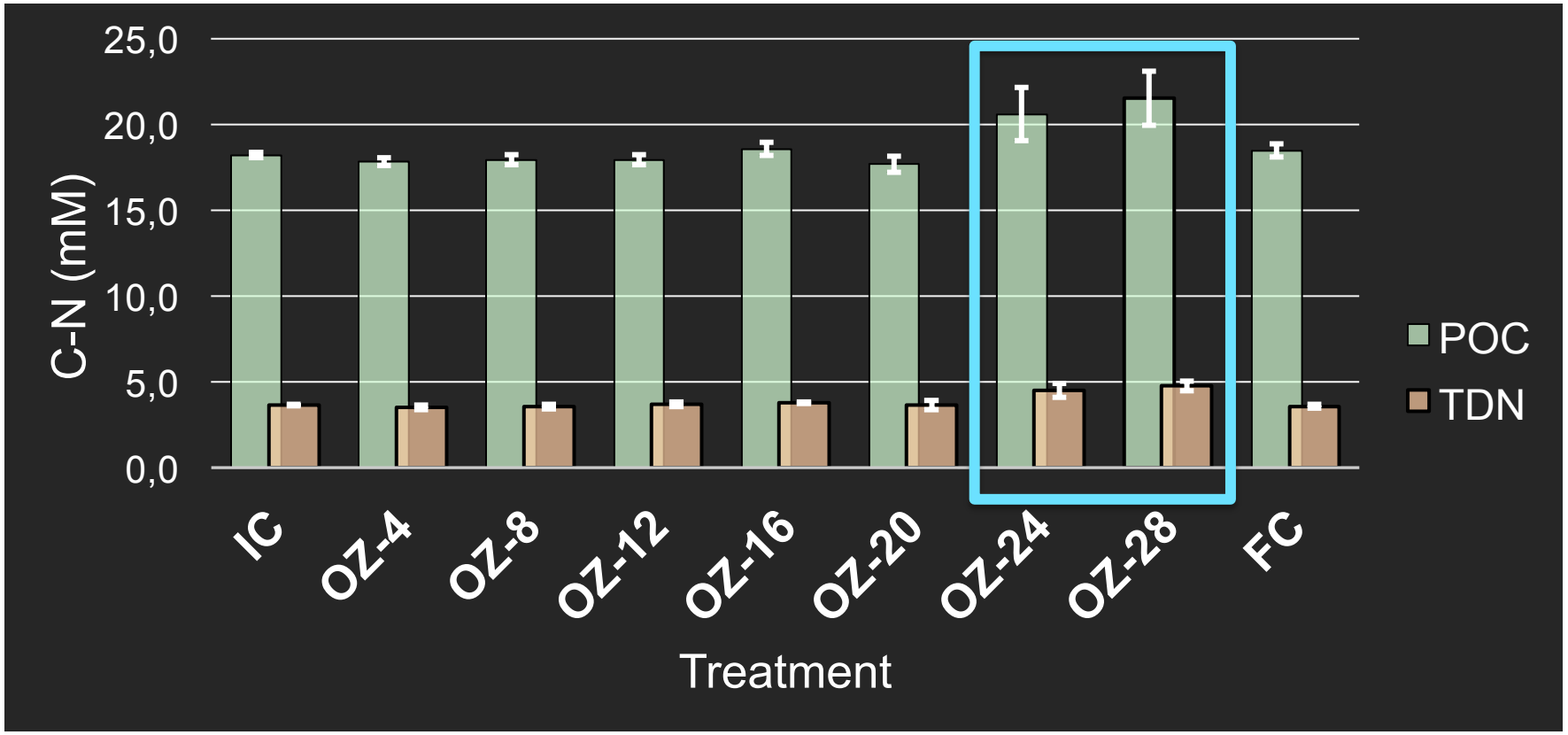
Ozonization experiments



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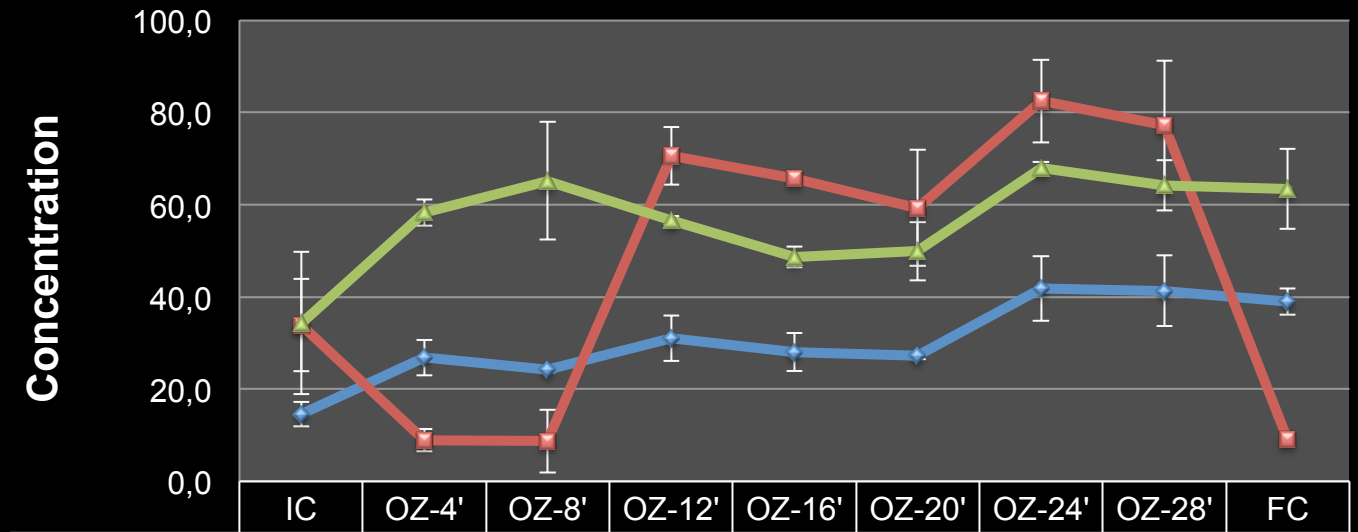
Accumulation processes

Other chemical species in the liquid phase



	IC	OZ-4'	OZ-8'	OZ-12'	OZ-16'	OZ-20'	OZ-24'	OZ-28'	FC
NH4_mM	14,59	26,84	24,27	30,97	28,03	27,19	41,82	41,29	39,00
NO2_mM	33,94	8,96	8,77	70,58	65,78	59,34	82,49	77,24	9,11
PO4_mg/L	34,27	58,32	65,19	56,65	48,67	49,90	67,97	64,20	63,47

NH_4^+(mg/L)	NO_2^-(mg/L)
1,10	2,56
2,64	0,88
2,61	0,94
1,12	2,56
1,13	2,65
1,19	2,59
1,51	2,98
1,66	3,10
2,89	0,68

NO_3^--N not detected

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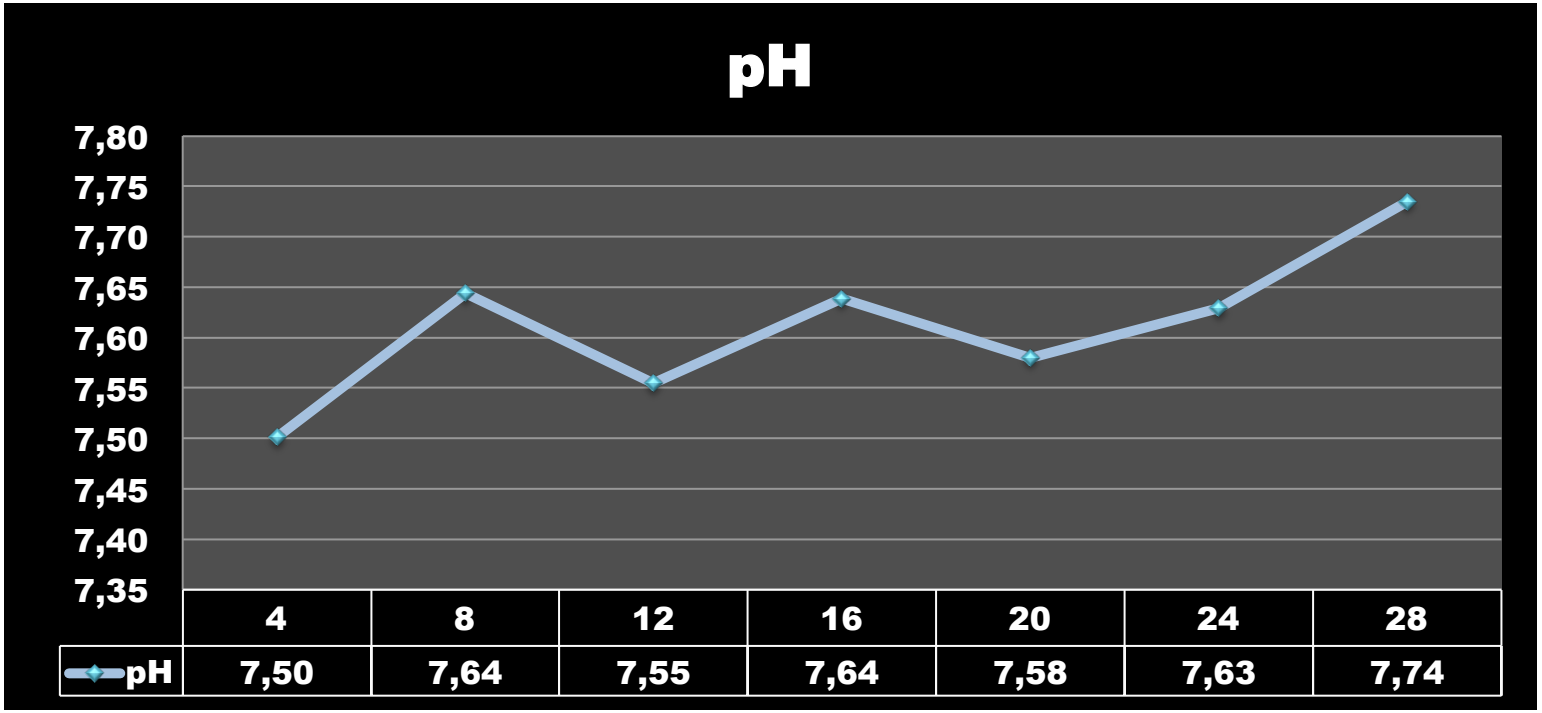
AcOMaCS: Activated Particulate Organic Matter as Carbon Source for Denitrification

Control parameters

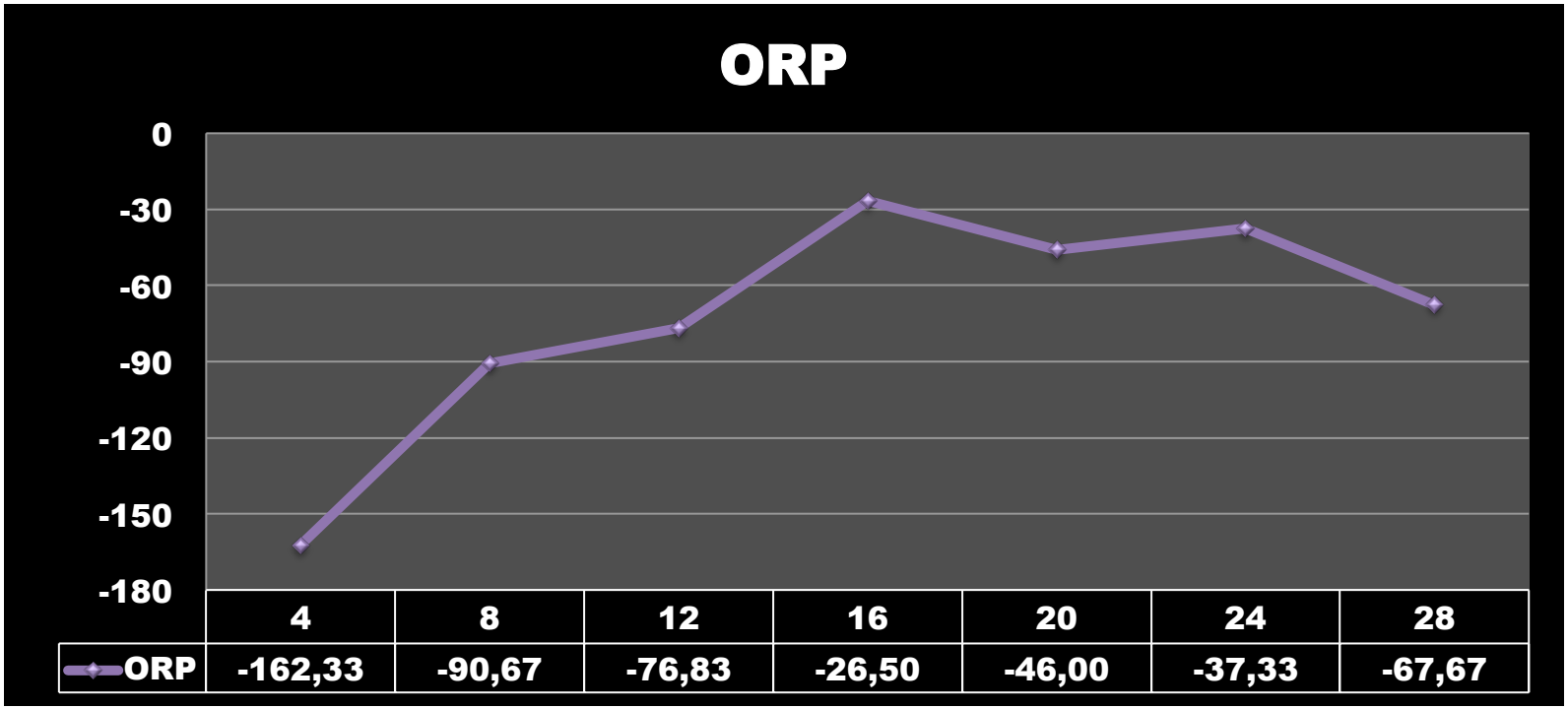


	4	8	12	16	20	24	28
pH	7,50	7,64	7,55	7,64	7,58	7,63	7,74

T=20,1 ± 0,3 °C

AcOMaCS: Activated Particulate Organic Matter as Carbon Source for Denitrification

Control parameters



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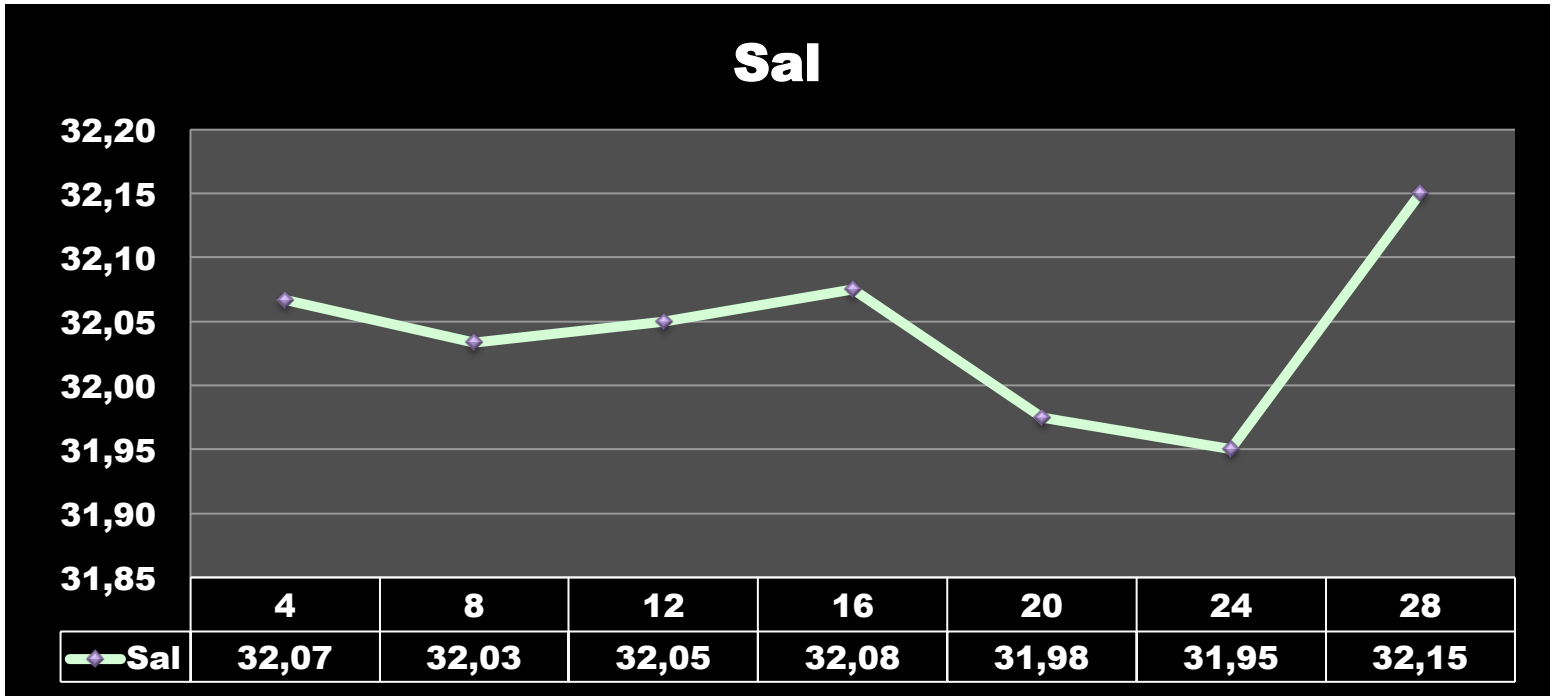


- Analysis of aminoacids, fatty acid and metal contents of residual sludge
- Determination of the maximum ozonization period to obtain the most Carbon sources from sludge in a feasible and economic way and its dependency on sludge age
- Determination of Denitrification performance at lab and RAS scale and the water chemical parameter which better describe the process and are prone to be used as controlling parameters
- Evaluation of possible negative impacts of the ozone-activated sludge as carbon source on bacterial community and reared fish
- Development and test at RAS scale of a sludge processing device based on ozone-activation

Next steps…

Conclusions

- The application of Ozone as oxidation/activation agent is effective in reducing sludge discharge out of a RAS.

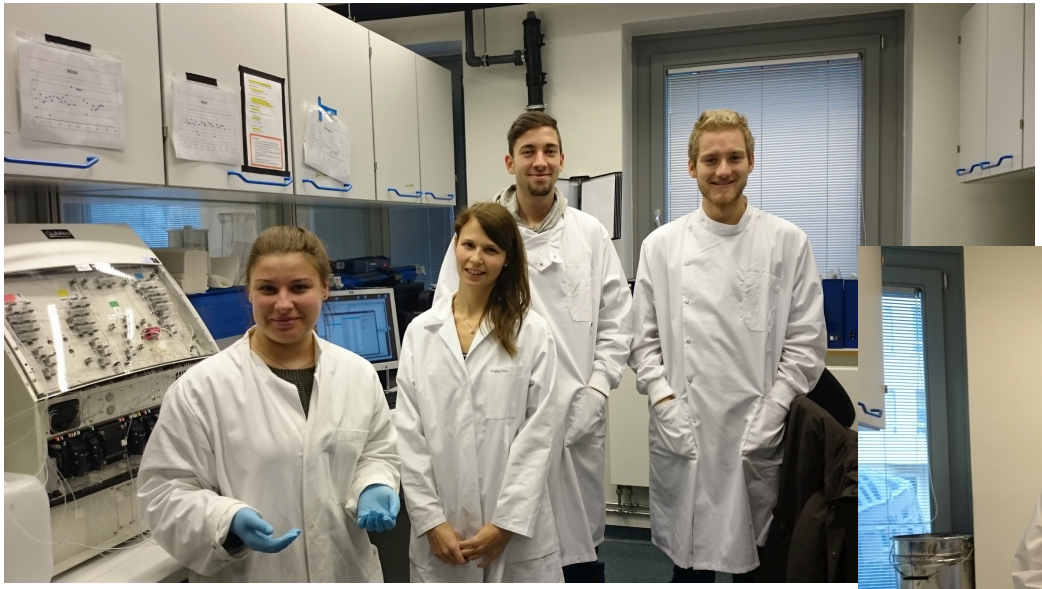
- Ozone leads to accumulation of Ammonium, Nitrite and Phosphate. This may force the denitrification reactor toward conditions favouring bacterial communities of the anammox genera as well as phosphate accumulating bacteria which may compete for the available carbon source.

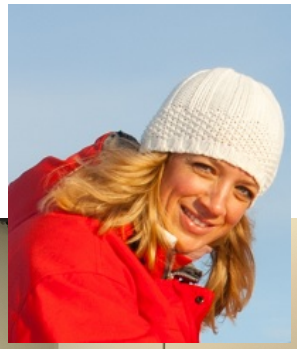
- At least 24 min ozonisation is necessary to obtain C:N ratios similar to those described in the literature as optimum for the denitrification process. As the main N-source in the ozone treated sludge will be Nitrite, faster reaction rates are expected to occur.

- Sludge age may influence the activation process and could require higher ozone concentrations or ozone contact time but will probably yield higher C_N concentrations.

Acknowledgments

Technical assistants (Timo Hirse, Sabine Strieben, Anja Sawicki and Mona Dannemeyer), other research sections of AWI which kindly offer their infrastructure facilities and advices (Prof. Boris Koch, Claudia Burau, Jana Geuer, Ute Marx), volunteers (Sarah Zwicker, Christopher Franz) and staff of the AQF Group and ZAF (Mirko Bögner, Kai Lorkowski, Rajko Thiele and Matt Slater).





Pictures: Webpage AWI and D. Bögner

Thank you!
¡Gracias!