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Biological Aerated Filters

BAF 2

Cranfield University
12th June 1996

Organised by:
The School of Water Sciences, Cranfield University
In conjunction with The IChemE Water Subject Group

Editors – Professor Tom Stephenson and Dr Bruce Jefferson

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**2nd Symposium on Biological
Aerated Filters (BAF2)
12 June 1996**

Following the success of the first BAF symposium held here in 1993, Cranfield University's School of Water Sciences is holding a second one day symposium on Biological Aerated Filters.

Over the last three years there has been a great deal of work on the development and optimisation of what has become one of the leading processes in wastewater treatment. The aim of this second symposium is to introduce recent work carried out in this field, bringing together many of the world's leading exponents of BAF technology and its application.

BAF2 represents an ideal opportunity to update your knowledge of these developments.

BAF2 Programme

- 9:30 Registration and coffee
- 10:25 Chairman's morning introduction
- 10:30 Trouble shooting and optimisation of BAF systems.
A Smith, Thames Water
- 11:00 Pilot scale comparisons of floating/sunken media and up/downflow BAFs.
A Mann, School of Water Sciences, Cranfield University.
- 11:20 Combined treatment of dairy and municipal wastewater in BAFs.
Howard Rundle, Tetra (Europe) Ltd.
- 11:40 North European experience of BAFs.
P Sagberg, Veas, Norway.
(to be confirmed)
- 12:00 The Poole Harbour wastewater treatment works.
P Brewer, Wessex Water Engineering.

- 12:30 Lunch
- 2:00 Chairman's afternoon introduction
- 2:10 The moving bed biological aerated filter
T Stephenson, School of Water Sciences, Cranfield University
- 2:30 Operational trials of different proprietary Lamella and BAF systems.
F Budge, Halcrow Consulting Engineers and D Gorrie, Grampian Regional Council.
- 3:00 Aeration optimisation in biological aerated filters.
P Pearce, Thames Water.
- 3:30 Operating performance and future development of the Biobed system.
A Cantwell, Brightwater Engineering.
- 4:00 *Close of Meeting and Tea*

The School of Water Sciences

The School of Water Sciences is the UK's only academic centre to specialise in process technologies for water and wastewater treatment. The school has considerable experience in research and development, working with many of the world's leading water companies and organisations concerned with water and effluent treatment. This experience ensures that the school is well positioned to offer consultancy and research and development related to these process technologies. The School has particular expertise associated with biotechnological applications including BAFs.

In addition to research and development and consultancy, the School of Water Sciences is recognised as a leading centre for the training of process technologies with funding from the EPSRC and approval of its programmes from the IChemE and CIWEM.

BAF and the biotechnology short courses have been developed to advance the understanding and implementation of these technologies.



Experiences with BIOFOR reactors at VEAS, Norway.

Paul Sagberg and Kirsti Grundnes Berg.

1 Introduction

VEAS is a municipally owned company treating the sewage from the city of Oslo and some neighbouring communities. Put in operation in 1982, the pre-precipitation plant removed up to 97% of the total-P and 70% of BOD from around 650.000 p.e.

Both the local situation in the inner Oslofjord and the political decisions of the countries surrounding the North Sea called for further treatment. Through 1989 and 1990, VEAS put bits and pieces of known technology together to compose a process for nitrogen and phosphorus removal to be installed in the area of the existing sedimentation tanks, only extended in depth. In addition, the process should reduce the amount of sludge considerably. A working hypothesis was presented in 1990 and later named "The VEAS Concept" by prof. H. Ødegaard, Techn. Univ. of Trondheim. The status for the development is described in more detail by Sagberg *et al.* (1995). Figure 1. show the state of the VEAS Concept by end of 1994. Further adjustments has later been made and new will be.

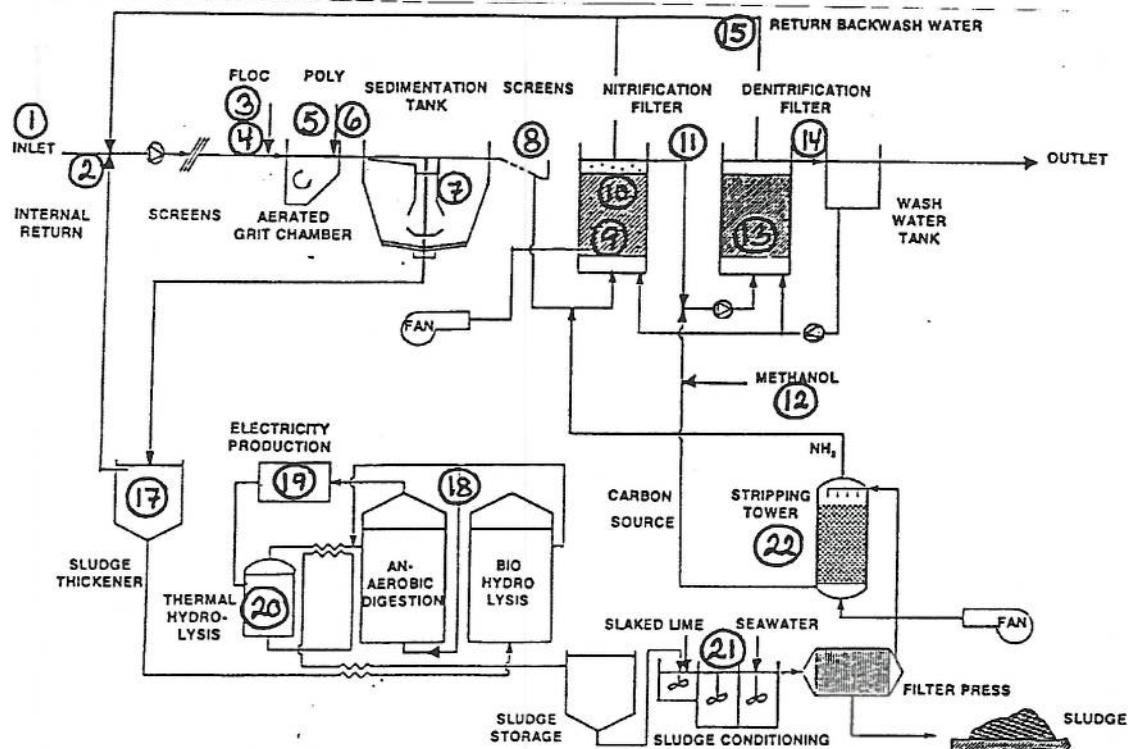


Figure 1 The VEAS Concept as of December 1994. The encircled numbers refer to the comments given in Sagberg *et al.* (1995)



Introductory tests were run by VEAS with RBC from Klargester, Mechana and Envirex, with submerged Munthers media, with the Kaldnes moving bed media and with the upflow BIOFOR system from Degremont. After international pre-qualification, call for turn key tenders, which were rejected, and finally licence negotiations, the BIOFOR system was selected for full scale application.

2 Testing of filter media for nitrification

As a part of the licence agreement with Degremont, the two companies should jointly use 2 mill. NOK to develop more effective filtermedia for nitrification. VEAS entered into an industrial development contract with the Norwegian company, Norsk Leca with support from the Industrial Development Fund. Approx. 10 mill NOK was the overall investment in the project.

A test battery of six columns, 50 cm in diameter with 4 m media thickness all fully automated were used in three series of testing Wien(1994-1995). Figure 2, show the arrangement of the test units. At the end of a serie, medias from two of the columns were interchanged to see if results were dependent on the spesific column used. Incoming water was the effluent water from the chemical pre-precipitation in full scale operation.

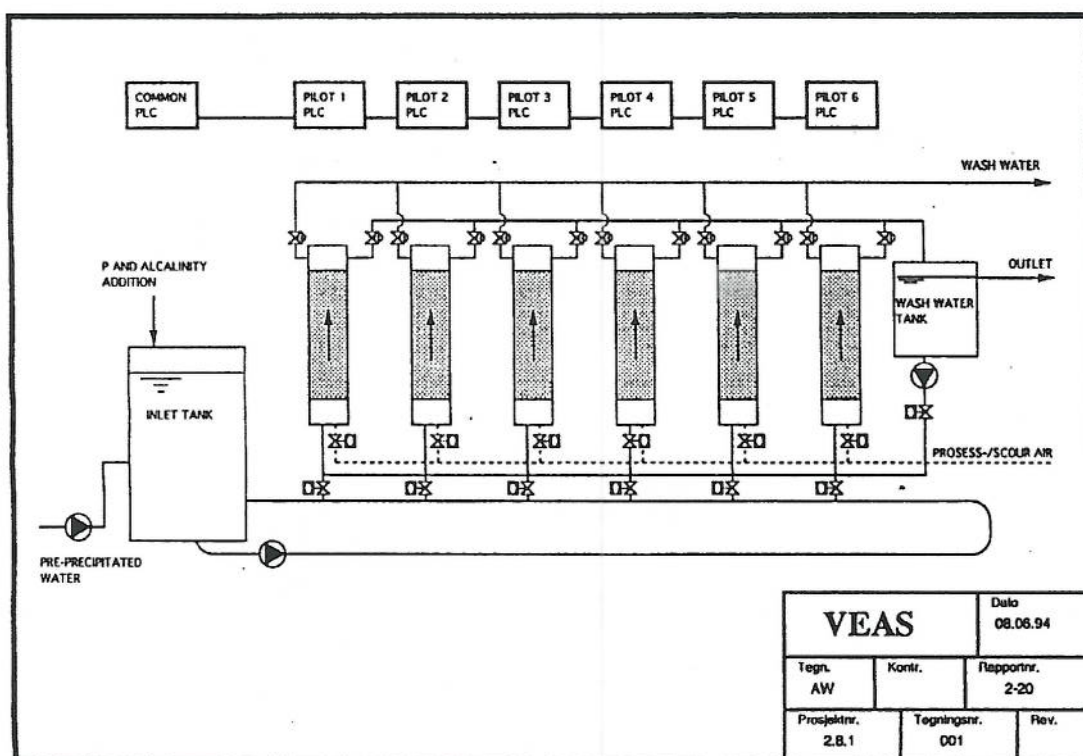


Figure 2 The arrangement of test units for filtermaterials in BIOFOR. Wien 2-21(1995)



The first hypothesis was that one should produce expanded clay aggregates as round as possible with as narrow span in size as possible. The idea was to get as good plug-flow conditions as possible ref. chromatography. Norsk Leca rebuilt their rotating furnace to produce small rounded aggregates which were sieved into quite narrow fractions. In addition round materials from German Liapor were tested. We included, however, a crushed medium from Lytag as reference. The results showed that the hypothesis was wrong in our two face system. The angular Lytag material was superior to the small uniformly sized rounded particles.

In the second serie of testing we tried larger aggregates and partially crushed materials. Again the Lytag material was superior, but the gap was closing. Media with the highest degree of crushing were better than the others.

In the last serie of testing all media were crushed. The most highly crushed material was superior to the Lytag material. Table 1 show the results from the three series of testing. All results are normalized with the Lytag results, each time started with fresh material. All results were compared to material meeting Degremont standard already installed in the first third of the full scale plant.

Table 1 The relative nitrification rates of 13 different medias tested in BIOFOR pilots at VEAS. Sagberg et al. (1995)

Type of carrier material	Fullscale	Reference	3	4	5	6	7
Relative nitrification rate, %	100	149	72	97	108	112	112
Type of carrier material	7	8	9	10	11	12	13
Relative nitrification rate, %	112	113	113	119	130	148	158

In addition to finding the materials with the best nitrification properties, the aim of the project was to find a cost efficient way of producing good materials. For VEAS the best solution was to sieve out the wanted fraction of round material for denitrification and then crush and sieve out the fraction wanted for nitrification. It was also important to develop strong materials that would tolerate hundred or even thousands of washings. The strength of the new materials was superior to others tested.



3 Discussion

What were the reasons for the good performance of the crushed materials? Larger effective surface either as microsurface or macrosurface could be an explanation. More biomass pr. unit of surface, better oxygen uptake or larger porosity could be others. We have no definite answer.

The porosity defined by the amount of water that could be drained from the filter did not correlate with the relative nitrification rate. The area of macrosurface did not alone seem to correlate nicely with nitrification rate.

In an other study conducted as a degree work by two students at the Agricultural University of Norway, in collaboration with VEAS, the biofilm on the expanded clay aggregates were studied in electron microscope. The pictures showed that the biofilm was extremely thin compared to biofilms on e.g. RBCs. The thickness of the film was only 10- 30 microns. All microscopic cracks were well inhabited and contributed significantly to the total surface area. Figure 3 a,b and c show three magnifications of the surface of one clay aggregate.

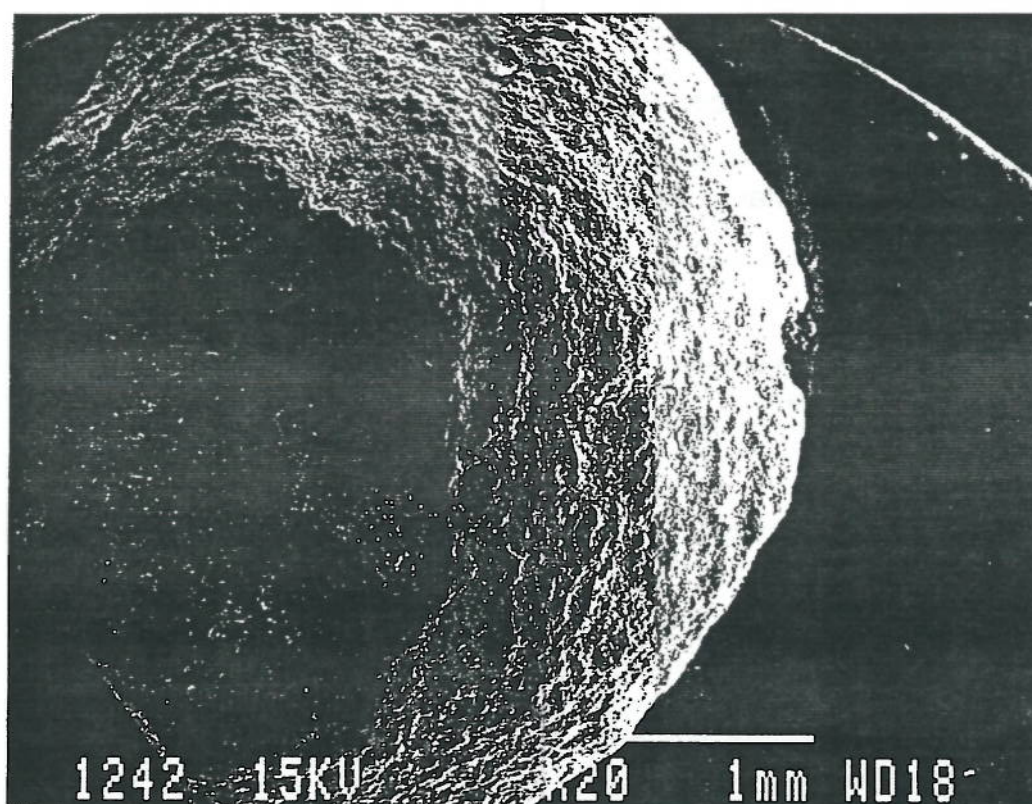


Figure 3 a.



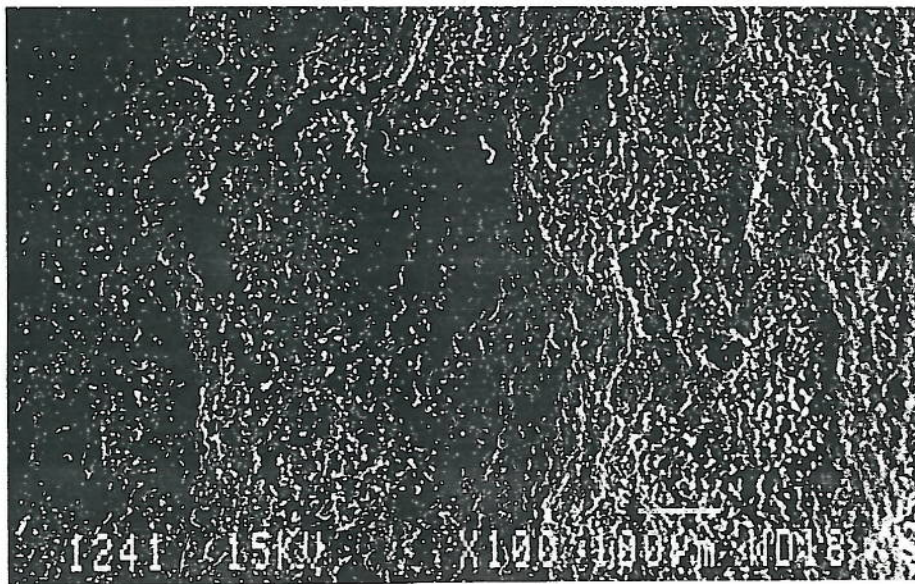


Figure 3b.



Figure 3c.

Figures 3 a,b,c. Three magnifications of surface of an expanded clay aggregate from the nitrification process at VEAS. Solheim and Jensen (1993)



It was observed that the dissolved oxygen in the water leaving the media with the highest nitrification rates, had not much lower values than the water from media with less nitrification, Wien 2-21 (1995), indicating that the oxygen transfer must have been better.

In another study by Ydstebø(1993), it was demonstrated that the oxygen transfer mechanism was a limiting factor to the nitrification rate. Exchanging normal air by air enriched with 36% oxygen, the nitrification rate increased significantly almost immediately. The results from one of the tests is seen in figure 4. The present biofilm had capacity to increase the nitrification rate spontaneously. A longer period of testing was not conducted to see if the biofilm in addition would grow in thickness.

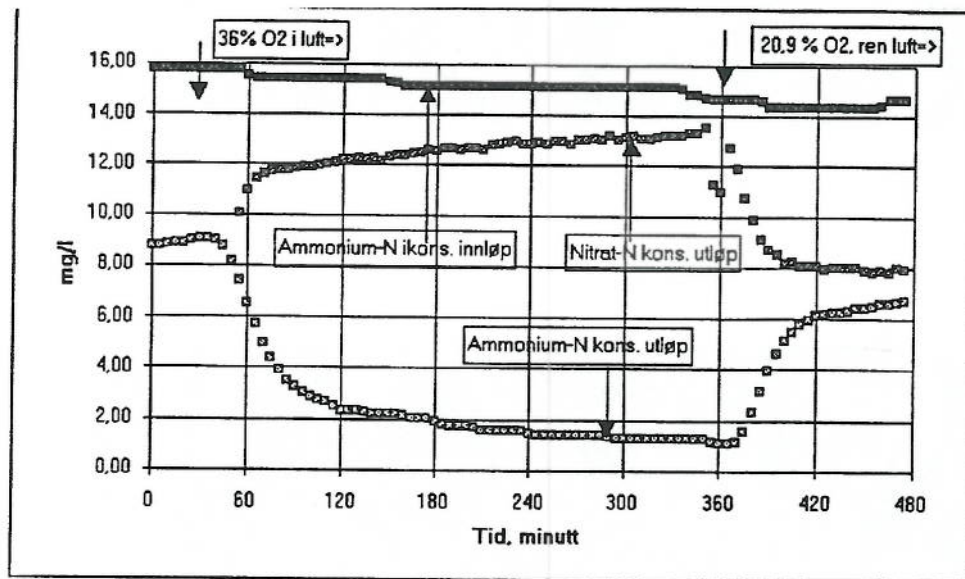


Figure 4 The effect on nitrification rate by exchanging air with oxygen enriched air (36% O₂) in a BIOFOR system at VEAS. Ydstebø (1992). Text in norwegian innløp=inlet, utløp=outlet, luft=air

4 Conclusions

By redesigning the rotating furnace for production of expanded clay aggregates and crushing of the media it has been possible to increase the nitrification rate of the BIOFOR reactors maintaining good strength and keeping production costs low.

The reason for the increased effectiveness is still obscure, but there is evidence that the effect is partly caused by increased micro surface and partly by better oxygen transfer with angular media.



5 Bibliography

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