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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 if 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.

School of Water Sciences

DEVELOPMENT OF A RECIRCULATING PLASTIC MEDIA BIOLOGICAL AERATED FILTER (REBAF)

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1 Introduction

True biological aerated filters (BAFs) combine two unit operations in one reactor: aerobic biological treatment and subsequent biomass separation from the effluent (Stephenson *et al.*, 1993). The submerged media used as support for the microbial biofilms are usually granular in nature and are therefore able to also act as depth filtration media. Therefore BAFs should provide a small footprint alternative to traditional aerobic processes. Indeed, Dillon and Thomas (1990) noted that a "good quality effluent" was possible up to a loading of 4.1 kgBOD/m^3/d (9.1 kgCOD/m^3/d); with an automated backwash programme influent BOD_5 was reduced by between 90.3 % and 97.6 %. Pujol *et al.* (1992) found an effluent standard of 90 mgCOD/l difficult to achieve for loading rates above 6.0 kgCOD/m^3/d. Stensel *et al.*, 1988) achieved 88 % removal of ammonia at a loading rate of 1.6 kgBOD/m^3/d and modern BAFs can achieve simultaneous carbonaceous BOD and ammonia removal at loading rates of 2.5 kgBOD/m^3/d (Rogalla and Payraudeau, 1987).

Despite the impressive loadings rates possible, BAFs require large volumes of water for backwashing on a regular basis to prevent blockage of the media. Therefore these processes require large volume tanks to hold effluent for backwashing and mudwells for collection of the backwash water. In addition, large pumps and pipework systems are needed to achieve the required backwash flowrates. In depth filters, this problem can be overcome by using continuous filtration systems, e.g. Dynasand (Kramer and Wouters, 1993). These incorporate a media recycle and wash system which allows uninterrupted treatment to occur. In Dynasand, the liquid flow is upwards and the media flow downward. The sand is removed from the base of the reactors, cleaned and then transported to the top of the bed. Thus the water exiting the filter always see a clean polishing layer of sand. The sand is removed by means of an airlift pump at the base of the reactor. Moving bed systems have been tested on sewage as an alternative to sedimentation (Mixon, 1973).

It is possible that the advantages of the moving bed principle could be combined with BAF technology to reduce or eliminate the need for expensive backwashing facilities. Such a system would not be the same as moving bed biofilm reactors described by Rusten (1984) and Hem *et al.* (1994) which require separate secondary sedimentation tanks. The current paper reports on an investigation into operating a plastic media BAF with media recirculation in order to eliminate backwashing.

2 Materials and Methods

The REBAF column is an upflow BAF containing granular plastic media to a depth of approximately 3 m. The main reactor was 5m tall, square in cross-section and tapered at the top and bottom. The empty bed volume was 0.75 m^3. Aeration was achieved with a sparge grid positioned just above the tapered bottom section. Influent primary settled sewage from the Cranfield University Sewage Treatment Works was delivered to the reactor at the same level as the aeration grid via a submersible pump (Jung Pumpen, Germany). The media in the column consisted of extruded polypropylene pellets approximately 4 mm long by 2 mm diameter (ICI Chemical and Polymers, UK). These had a specific gravity slightly less than that of water, traveled up the column, co-current with the liquid flow, and were removed from the top of the bed by a screw (Fig 1).

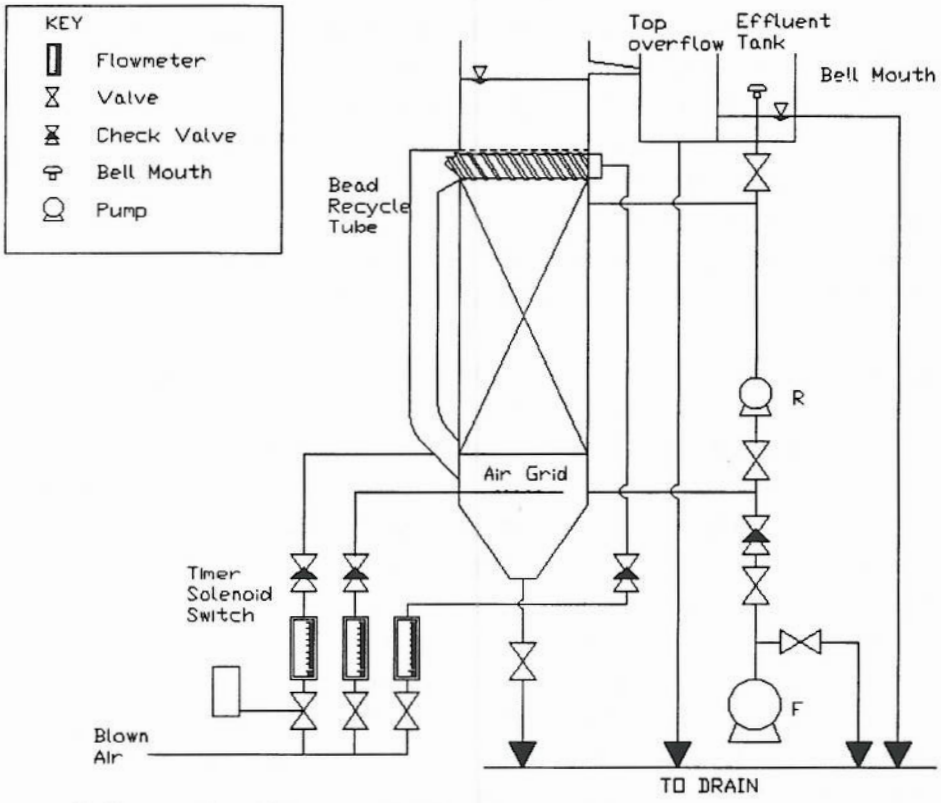


Figure 1 Schematic of the REBAF column

The removed media was then forced down a recycle pipe and entered the column towards the base, at the same level as the influent settled sewage feed and the process air grid. The screw at the top of the bed was also fitted with an air sparge, if required. The column width was greater than 50 times the media size, so represented a full-scale system in terms of depth filtration properties (Lang *et al.*, 1993). Treated effluent could exit the reactor either via a collection duct 0.3 m from the top of the bed or at the top above the bead return screw.

The column was operated in one of two modes: continuous bead recycle or intermittent bead recycle. In continuous mode, the screw speed was set to recycle all the beads

every 24 h. In intermittent mode, the length of time the bead recycle was on could be adjusted on an automatic timer and was usually between 15 and 60 min. During the bead recycle period, the influent remained on. After start-up, the rig was operated in continuous mode for 21 d followed by intermittent mode for 45 d. During each operating period the influent flowrate, and therefore BOD loading, was steadily increased.

Performance was measured by comparing the influent and effluent concentrations of COD, soluble COD (sCOD), suspended solids and ammonia; analysed according to standard methods (APHA, 1989). In addition, the temperature and pH were also monitored. BOD removal rates were obtained by performing a number of BOD tests to establish BOD:COD ratios for the settled sewage and treated effluent. It was found that the influent COD:BOD was and the effluent COD:BOD was 2.0:1 and 4.9:1.

3 Results and discussion

Following start-up of the REBAF, the column was operated with continuous bead recycle for a period of 21 d. During this period the influent flowrate was from 2.0 l/min to 6 l/min; corresponding to a decrease in empty bed contact time from 6.3 h to 2.1 h. The influent COD of approximately 350 mg/l was reduced to approximately 50 mg/l in the effluent (Fig. 2). this showed that removal of organic material by biological action was occurring. However, the suspended solids removal was very poor, indicating that no depth filtration action was occurring (Fig. 3).

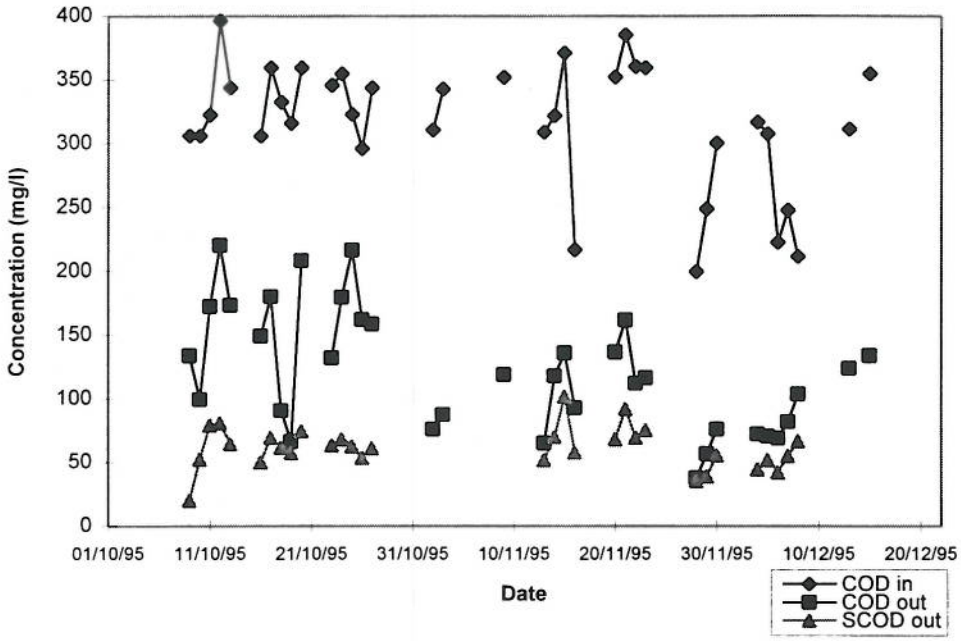


Figure 2 Influent COD and effluent Total and soluble COD (SCOD)

On day 22 the REBAF was switched to the intermittent mode of operation and flow kept at approximately 4.5 l/min; corresponding to BOD loading of 1.4 kg/m^3/d. Initially, the bead recycle was on for 1 h in every 24 h and recycled one sixth of the bed volume

each time. Effluent COD decreased (Fig. 2) and there was a corresponding fall in effluent suspended solids (Fig. 3). The average BOD removal for the period 2/11/95 to 23/11/95 was 87% with an average effluent suspended solids of 32 mg/l; a reasonable performance compared to other systems treating settled sewage (Pujol *et al.*, 1992; Smith and Hardy, 1992).

Effluent suspended solids were closely monitored during the bead recycle period on five occasions at four different flowrates corresponding to BOD loadings of 0.8 to 2.2 kg/m^3/d (Fig. 4.). Effluent suspended solids recovered within 30 min; comparable to the post-backwash recovery of dense media BAFs (Smith and Hardy, 1992). As perhaps expected, solids removal was greatest at the highest influent flowrate. A solids mass balance was performed on the day of the bead recycle at the 5.7 l/min flowrate. The influent and effluent BOD were 161 mg/l and 24 mg/l respectively which accounted for production of 1.08 kg of sludge, assuming 1 kg of sludge produced per kg of BOD removed. Solids leaving the reactor were calculated from the suspended solids collected in the base of the reactor, in the effluent during 23 h of normal operation, and during the bead recycle period. This came to 1.02 kg with 64 % accounted for by the recycle period. Therefore nearly all the biomass was being lost every 24 h. The final part of the trial looked at reducing the bead recycle time to 15 and 30 min. The former time was too short due to more rapid build up of headloss. On 12/12/95 the bead recycle time was raised to 30 min a day, corresponding to recycling approximately 8 % of the beds. Performance was good at the BOD loading of 1.4 kg/m^3/d under this regime (Figs. 2 and 3).

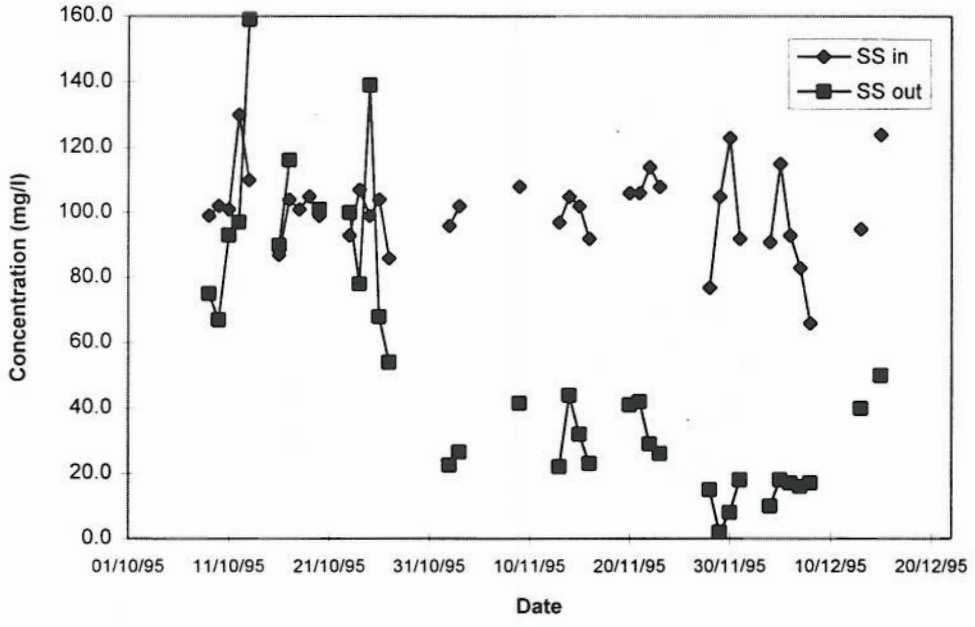


Figure 3 Influent and effluent suspended solids (SS)

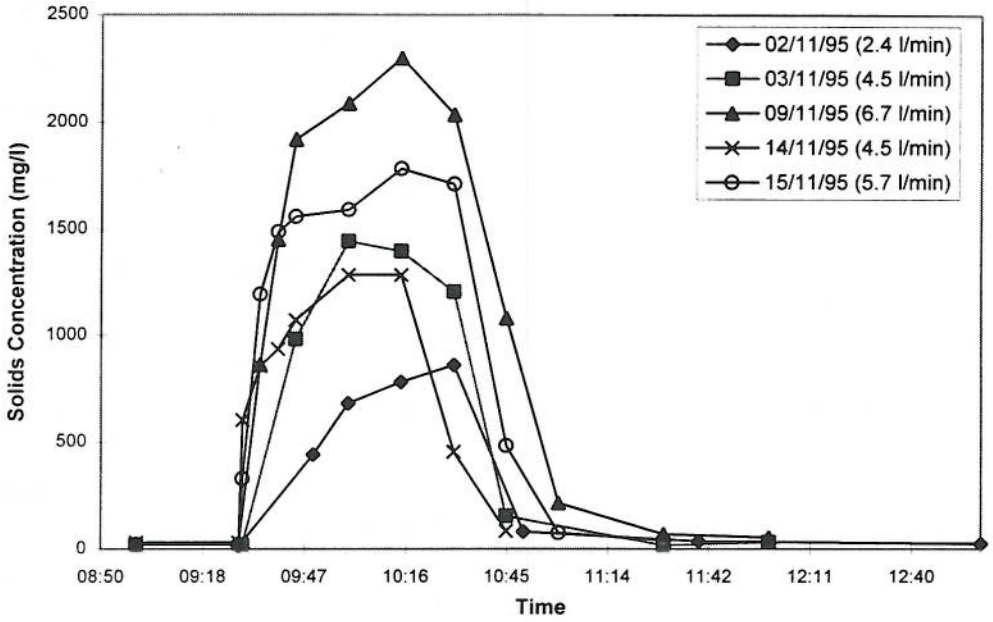


Figure 4 **Effluent suspended solids during bead recycle period at different influent flowrates**

4 Conclusions

The concept of recirculating media demonstrated promise in developing a BAF that does not need backwashing facilities. Suspended solids and BOD removal performance of the REBAF at loadings similar to other reported systems were comparable. Further work is needed to optimise the bed design, in particular media selection and time and speed of media recalculation.

5 Acknowledgements

The author wishes to thank Comenco Ltd, London UK, for permission to publish this work. The help of Allan Mann and Sam Harris with the practical work is gratefully acknowledged. A version of this paper has been submitted for the International Association on Water Quality's Biennial Conference in Singapore, June 1996.

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