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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

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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

POOLE WASTE WATER TREATMENT BAF PLANT

Peter Brewer, Bsc, Ceng, MICE, MCIWEM, Principal Engineer,
Wessex International Water Services

NEED FOR EXTENSIONS

1. The town of Poole in south east Dorset has undergone substantial development during the 1980's. Wessex Water recognised the pressure on the water services in this region and commissioned a strategy study for this region. This resulted in a proposal to extend each sewage treatment works in that area up to a standard required by the receiving watercourse.
2. The 2 main river catchments are the River Stour and River Avon. The latter flows into Christchurch harbour in the east, whilst the Stour flows into Poole Harbour. Poole WWTW discharges directly into Holes Bay in the upper reaches of Poole Harbour.This tidal estuary is of national importance in environmental terms, whilst being extensively used for recreation.
3. Consultations with the National Rivers Authority (now the Environmental Agency) led to a discharge standard of 20 mg/l BOD; 30 mg/l SS;10 mg/l Amm N on a 95 percentile basis being accepted for design of the extensions. Indications are that in the long term nutrient removal and disinfection may well become a necessity. The EA has plans to conduct extensive surveys of Poole Harbour in the next few years.
4. The extensions to Poole WWTW will raise the treatment capacity from a population equivalent of 129,000 to some 151,000. Dry weather flow will be 46,700 m3/d, and flow to full treatment will be 17,700 m3/d at the 12 year planning horizon. These extensions now provide a treatment plant with some 48% increase in hydraulic capacity, whilst producing a fully nitrified effluent.
5. The existing treatment plant consists of essentially two separate plants, known as eastern and western, both activated sludge plants. The site is quite close to the historical town centre, and growth in the town over the last half century has extended well beyond the works site. Consequently, the works is now completely surrounded by development fro housing to light industry. Indeed, we now have the benefit of a major supermarket on our southern boundary, some 20m from the inlet pumping station!

TREATMENT PROCESS SELECTION

6. The physical location of the works in close proximity to such development had a major influence on the process selection. Early appraisal work had compared on-site extensions with relocating well out of the town, but relocation was ruled out on substantially higher costs.
7. Thus an evaluation of all processes was conducted in 1990 to find one which would satisfy all the objectives set down by Wessex Water, not only in terms of effluent compliance, but essentially in environmental control of noise, odours and aesthetic design. All this had to obtained in a plant limited in size by the existing available land within the works boundary.

8. Process calculations determined a new treatment stream with a capacity of 28,000 m3/d dry weather flow, and 64,000 m3/d peak flow would be required. This would treat a daily BOD load of 6,973 kg and an ammonia load of 804 kg. Furthermore, a second stream had to allowed for future extensions beyond the year 2010.
9. This basically defined an available land area of 135 metres by 40 metres on the site of the original sludge drying beds. Such a size of plant meant it became economic to cover the plant and enable odour and noise to be rigorously controlled.
10. It was during this period that the biologically aerated filter (BAF) was becoming established as a viable process in the UK following success on the continent. The compact BAF plants, in the form of Biocarbone and PWT Safe, were carefully evaluated. Coupled with lamella technology for primary sedimentation, these offered a positive solution for the restrictions experienced at Poole. Detailed economic evaluation followed, which verified this process both in capital and npv terms.

THE SOLUTION

11. Wessex Water decided to utilise the specialist knowledge of process contractors and compiled a contract under the IChemE Model Form of Conditions of Contract for Process plant - the Red Book. The scheme was advertised under the EU Procurement Directive and a short list drawn from those applicants who could demonstrate a proven process of a similar size.
12. To provide data of the raw sewage characteristics for the tender documents, a comprehensive diurnal sampling and flow measurement programmme was undertaken. Potential tenderers were involved at this stage. The list included total and soluble BOD, total solids, total and soluble COD, TKN, ammonia, temperature, pH, chlorides, sulphates and fats,oils and grease. A particular point of interest to the process engineers was the identification of a peak ammonia load each morning.
13. The successful contractor was Degremont UK Ltd of Dunstable who proposed a fully integrated process using their own technology of Densadegs and Biofors. This treatment concept is well established as being efficient in performance and in space requirements. At Poole, it met all our overall objectives.
14. The standards of performance in the contract were quite stringent and covered effluent, noise, odours, and revenue criteria. The process units designed by Degremont to meet these standards comprised of:-

- Densadeg primary treatment tanks with chemical dosing and lamella settlers. These units incorporate partial sludge recycling and sludge thickening.
- Biofor units arranged in 2 stages for biological treatment; carbonaceous and nitrification. The Biofors are periodically backwashed to remove suspended solids and by their nature there is no need for separate final settlement tanks.

15. Process data is appended, and a fuller description of each stage follows. The main project allowed for preliminary treatment of all flows into the works, This consists of 6 nr. fine screens of 6mm spacing; grit and grease removal; storm separation and flow division to feed each of the 3 treatment streams. The BAF plant caters for 60% of the total works flow.

DENSADEG PRIMARY TREATMENT

16. Screened sewage from the Inlet Works enters the Primary Treatment Building and passes into one of the 3 Densadeg units. The first chamber provides for flash mixing of ferric sulphate to pre-condition the sewage. Flow then passes up into the flocculation chamber for polyelectrolyte dosing. This chamber is larger and contains a turbine mixer installed within a baffled tube. Sewage is pulled up through this tube and a cylindrical pipe injects the polymer into the flow.

17. The sewage then flows from the base of this chamber up over a submerged weir wall into the settling chamber. A manual scum draw off is fitted at this point to pull off any remaining grease coming out of suspension.

18. In the settling chamber the flocculated solids descend to the floor as a sludge blanket establishes. The flow then passes up through the lamella section for clarification. The lamellas used at Poole are 80mm tubular plastic packs, 900mm deep. Stainless steel notched troughs collect the settled sewage and passes the flow to the main outlet channel.

19. The settled sludge is thickened in the base of the Densadegs by a continuously rotating picket fence mechanism. This also incorporates a scraper which directs sludge to the central sludge hopper. Level probes in the settling chambers control the sludge extraction. Each tank has three positive displacement - progressive cavity - pumps installed. One pump recycles a proportion of the more dilute top sludge layer from this tank back to the flocculation chamber inlet pipe to further assist the flocculation process.

20. A similar pump periodically wastes sludge to the existing site digestion tanks. This waste sludge is extracted at 6% dry solids by weight. The pumps deliver to existing storage tanks where the sludge is blended with the surplus activated sludge from the other two treatment streams. All sludge is then anaerobically digested prior to disposal to farmland.

21. Each Densadeg tank is also fitted with a range of sampling points to assist the operator in monitoring and control.

BIOFOR BAF SECONDARY TREATMENT

22. Settled sewage from the Densadegs flows along the Biofor inlet channel to the stage 1 cells. The Biofor is a biologically aerated filter containing a fixed, submerged, granular bed operating in co-current flow mode. This means the sewage flows upwards through the bed, in the same direction as the process air, giving maximum contact time with the air.

23. The 8 nr. Biofor stage 1 cells provide carbonaceous oxidation of the sewage through the activated fixed biomass, whilst the 18 nr. stage 2 cells provide nitrification. Each stage operates in an identical method; the only difference being in the number of cells per stage and the depth of media. The stage 1 cells are 3 m deep, and the stage 2 cells are 4 m deep. Hence, the treatment capacity necessary for nitrification is considerably greater than that for BOD removal.

24. The number of cells was determined by Degremont in their process design, and was very much influenced by the peak ammonia load through the works during a small period, and also by the lower temperatures in the UK. The process allows for

performance to be maintained with 1 cell being backwashed and 1 cell out of service for maintenance.

25. Each Biofor cell operates the same way. Inlet flow from the feed channel passes over a weir into the inlet box containing a 3mm screen, and drops to the base of the cell under a plenum floor. The settled sewage passes up through nozzles in the concrete plenum floor which supports the granular bed. A system of Oxazur membrane air diffusers above this floor distributes the process air into the sewage as it passes up through the bed.

26. An individual blower provides process air to each Biofor cell. Two spare units are held locally to provide standby capability. Air is blown through a syphon unit over the tank wall and down through the media into distribution manifolds.

27. Treatment in the Biofor cells causes organic matter to be retained within the media, and this needs to be removed periodically by backwashing the cell.The stage 1 cells need to be backwashed every day, with the stage 2 cells every 2 days. Cells are cleaned in sequence on a timed rota basis with an override on headloss through individual units.

28. A large air scour blower, with a standby unit, is used for backwashing together with a wash of final effluent in a pre-determined sequence. The normal outlet of the cell is closed and the backwash discharge, containing the excess biomass solids, is diverted to a holding tank. From there it is bled back into the primary treatment tanks for ultimate removal in the sludge stream.

INSTALLATION

29. The process design by Degremont was translated into a civil works design and a contract awarded to a joint venture, Wimpey Wessex Water, for construction. The primary treatment tanks and odour control units are housed in a building. A similar building at the other end of the Biofor cells houses the pump hall and main MCC and ICA rooms. The Biofor cells themselves are not covered, although provision has been made for adding covers later if required.

30. At a suitable point of the civil construction Degremont commenced their installation of pipework, mechanical and electrical work. The pipework itself was very extensive to cater for process air, air scour,and washwater as well transfer flows between the tanks.

31. Mechanical plant included process equipment and building services equipment:-

- Process air blowers,1 nr. per Biofor cell plus 2 nr. spares, 28 nr. total
- Air Scour blowers, duty and standby, to serve all cells in sequence
- Rotork actuated valves, approx 120 nr., for sequencing cell backwashing
- Transfer Pumps, duty and standby, to lift sewage from the Stage 1 to Stage 2 Biofors cells from a large transfer tank
- Backwash water pumps, for large volume backwashing of the cells with water
- Air Handling units to introduce fresh air into the plant
- Gas fired boilers to preheat the air and also for domestic heating to the buildings
- Densadeg picket fence thickener mechanisms, 3 nr.
- Chemical dosing pumps and stirrers
- Main Ventilation fans, 2 sets of duty and standby
- Miscellaneous minor plant

32. Electrical installation was even more extensive, from the 2 nr. 1.5MW transformers to several kilometres of cabling. Standby generators are installed to maintain power supplies at all times. The main MCC is over 55 m long, with separate MCC's for Building Services (ventilation and odour control) and for fire and gas alarm systems.
33. As previously mentioned, a main criteria of this plant is the full odour control system. Fresh air is drawn into the plant in both the Control Building and in the Primary Treatment Building. This is used not only to ventilate all areas of the plant but specifically to provide the air for the process air blowers. Two separate extraction ductwork systems are installed for foul air; one for the primary treatment and pipework galleries and the other for the Biofor cells.
34. Foul air is passed through a 2 stage chemical scrubbing system prior to discharge to the atmosphere; this is duplicated to match the two extraction systems. The chemical scrubbing utilises sodium hypochloride and sodium hydroxide. The scrubbing towers are packed with random plastic media and as air is drawn up through the towers, diluted chemicals are sprayed downwards. Recirculation pumps recycle this liquor and topping up of chemicals is controlled by pH and Redox sensors.

COMMISSIONING

35. Alongside of the design and installation have been studies into Hazardous Areas and COSHH assessments. Naturally these have an impact on the equipment supplied and should be carried out at an early stage. Reviews are necessary to accommodate any changes during design and installation. As with CDM regulations, many hazards are designed out where possible.
36. Since the autumn of 1995, the contractor and supervisory staff have been engaged on functional testing and then setting to work. The complexity of the plant cannot be emphasized enough and requires sufficient programming. On the 3 rd January 1996 we turned flow into the primary treatment area and put the chemical dosing and Densadeg units to work.
37. This took some setting up of conditioning to do, and units had to be proven individually. Only once the whole of the primary treatment was operating securely could we allow sewage flow to go to the Biofor 1 stage. This was in March 1996.
38. Initially, the whole backwash sequencing of the Biofors had to be proven. This work was quite extensive as it relied heavily on the software control systems. Once this was checked out, then the biomass could be started. The effluent was monitored and returned to the inlet.
39. When, by early April, the BOD was sufficiently reduced, the stage one effluent was then passed onto the stage 2 Biofors and the process repeated. By early May nitrification was achieved and we could move onto the final phase of setting to work.
40. On the 13 May 1996 we commenced the formal 14 day performance tests of the BAF plant. Degremont were responsible for operating the plant and proving to the Purchaser not only that the Final Effluent standard could be maintained, but that the whole plant could be operated within defined limits. Thus on the 3 June 1996 Handover to Wessex Waste Water Services was achieved.

41.A 12 month maintenance period is now under way, with 2 further extensive sampling periods for summer and winter compliance, and performance monitoring of revenue parameters over this whole period as per contract schedules.

POOLE WASTE WATER TREATMENT PLANT EXTENSIONS

1. POPULATION AND FLOWS

Population served will be primarily domestic, 151,000

Dry Weather Flow	BAF Plant	28,000 m3/d
	Eastern Works	10,020
	Western Works	9,120
		47,140
Flow for Full Treatment	BAF Plant	64,000 m3/d
	Eastern Works	23,400
	Western Works	20,300
		107,700

2. CONSENT STANDARD

Proposed Consent Standard	20 mg/l	BOD(5)
	30	Suspended Solids
	10	Ammoniacal Nitrogen

3. PRELIMINARY TREATMENT

The Inlet Works Building houses 6 nr. Fine Screens, Aquaguard, arranged in pairs in 3 nr. channels, providing 6mm screening and screenings compactors.
2 nr. Aerated Grit and Grease removal basins, with grit classifiers.
Storm Overflow and Flow Division control flumes and penstocks.

4. PRIMARY TREATMENT

The Primary Treatment incorporates chemical addition for flocculation and settlement through 3 nr. Tanks 10.4 m square, fitted with lamella plates and picket fence thickener mechanisms.

5. SECONDARY TREATMENT

Secondary treatment is done in 2 stages; carbonaceous oxidation and nitrification.

1st stage Biofor cells, 8 nr., each 9.27 m by 7.88 m and 3.0 m media depth.

2nd stage Biofor cells, 18 nr., each 9.27 m by 7.88 m and 4.0 m media depth.