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Biological Aerated Filters

BAF 3

Cranfield University
Wednesday 3rd March 1999

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3rd International Meeting on Biological Aerated Filters – BAF 3

Wednesday 3rd March 1999 - Cranfield University

Following the success of the first 2 BAF meetings held at Cranfield University, the School of Water Sciences is holding a third one day international meeting on Biological Aerated Filters.

Since BAF 2 work has progressed on the development and optimisation of BAFs in wastewater treatment. The process is now operated in the UK. Further refinements to the process have also increased the potential of BAF technology to a wider range of applications.

The aim of this 3rd meeting is to review the latest research work related to BAFs, examine operating experiences and consider future market potential for the BAF process.



INDUSTRIAL APPLICATIONS OF BIOLOGICAL AERATED FILTERS

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1. Introduction

Biological aerated filters (BAF's) are compact wastewater treatment reactors capable of achieving biological oxidation and solids removal in a single reactor. The basic principle of operation is that biomass grows on the surface of a submerged medium. Air is injected at or near the base of the medium. The effluent to be treated flows either upward or downward through the bed. Biological oxidation occurs during passage through the bed and suspended solids are retained within the bed. These solids are removed periodically by backwashing. The use of BAF technology is well known for treatment of municipal sewage. The application of this technology to industrial effluents is less well documented.

In this paper the application of the TETRA ColOX™ BAF to treatment of effluents arising from paper making, from steel making, from plastics manufacture and from the electronics industry is described.

2. The TETRA ColOX™ BAF

The TETRA ColOX™ BAF is a direct development of the TETRA deep bed filter of which there are over 100 installations worldwide and over 30 in the UK and Europe. These installations treat flows of up to 300,000 m³/d and are used in both industrial and municipal applications.

The heart of the system is a patented robust filter bottom design, which has no nozzles and no moving parts. This system can be used in either upflow or downflow modes. A process diagram for upflow operation is shown in Annex 1

Influent enters via a channel under the TETRA T blocks and rises through gaps between the blocks into the gravel layers. The filtration medium is located above the gravel layers and normally consists of 2 to 3 mm rounded silica sand. The sand used has a very high specification for hardness, roundness and uniformity. Because of the robustness of the filter bottom it is possible to have very deep beds of medium. 4 metres are usually used. Process air is added from stainless steel laterals located under the blocks. There are no diffusers or other orifices to block or break and cause problems. During backwash, flow is shut off to the cell and an intense air/water scour of the media bed is carried out. This intense backwash removes excess biomass from the system. Backwash volumes are between 5% and 10% of throughput.

This design has been proven both in the deep bed filters and in the associated anoxic Denite™ filters. There have been no failures of the filter bottom in over 20 years of use.

3. INDUSTRIAL APPLICATIONS

Four industrial applications are to be described:

- 3.1. Rock Tenn Co paper mill, Delaware Gap Pennsylvania USA.
- 3.2. Monessen Steels
- 3.3. Formosa plastics plants at Jen-Wu and Lin-Yuan in Taiwan
- 3.4. Hyundai Electronics plant in Ichon ,Korea.

4. Rock Tenn Co Board Mill

This company manufactures cartons from recycled paper. Effluent is derived from a variety of processes. The effluent is degrittied, and flow is balanced. The effluent is cooled to below 35°C and the pH corrected. Nitrogen and phosphorus added before treatment in two ColOX™ reactors. These reactors are circular tanks each 3 metres in diameter with a 4.2m depth of medium. Typical monthly performance of this plant is shown in table 1.

TABLE 1 average performance of ColOX™ treating board mill waste.

Parameter	Raw effluent	Treated effluent	% Removal
BOD mg/l	3660	1250	78
COD mg/l	5280	1920	64

The average flow to this unit is 79 m³/d and the BOD load 4.9kg/m³ of medium per day. The site of the effluent treatment plant is very restricted and subject to flooding. The plant has been designed so that all controls are above flood level.

5. Coke Plant Wastewater Treatment at Monessen Steelworks

Monessen coke plant is a small steel mill coke plant, which generates up to 654m³/d of wastewater containing cyanides, phenols, thiocyanates and ammonia. Originally the effluent was treated by an activated carbon filtration system but this was expensive to operate and inadequate to meet the more stringent effluent standards. A five-month pilot programme was undertaken to prove the process and optimise the design. The ColOX™ biosystem was selected after testing of other chemical; physical and biological treatment plants had been evaluated.

The coke wastewater treatment plant consists of equalisation, pH adjustments, ColOX™ aerobic system and sludge disposal. The heart of the treatment plant are the six ColOX™ reactors. Each reactor is 2.9m wide X 6.5m long and contains 4m of 2 to 3mm silica sand and support media. The process airflow rate is 42.5m³/min.

The plant was commissioned in 1996 .It started up quickly. Two sets of results are available these are summarised in table 2.

TABLE 2 Performance of ColOX™ Plant Treating Coke oven effluent

PARAMETER	RESULTS DEC 96-JAN 97	RESULTS AUG 98-SEP 98	UNITS
BOD LOAD AVERAGE RANGE	0.33 0.18 to 0.49	0.88 0.51 to 1.2	Kg/m ³ d Kg/m ³ d
NITROGEN LOAD AVERAGE RANGE	0.33 0.19 to 0.51	0.2 0.16 to 0.34	Kg/m ³ d Kg/m ³ d
PHENOL CONC ^N INFLUENT EFFLUENT REMOVAL	50.4 < 0.5 >99	183 0.058 99.97	mg/l mg/l %
THIOCYANATE CONC ^N INFLUENT EFFLUENT REMOVAL		374 2.0 99.5	mg/l mg/l %
TOT UNOX NITROGEN CONC ^N INFLUENT EFFLUENT REMOVAL	265 24.1 91	181 15 91.7	mgN/l mgN/l %

These results show that the plant is capable of consistently achieving a high degree of removal of phenol and cyanide species. Not only is the plant able to oxidise ammonia, which is present in the influent, it also is removing ammonia which is generated as a breakdown product of cyanide and thiocyanate.

6. Electronics Industry Wastewater Treatment at Hyundai Electronics Industries, Ichon, Korea

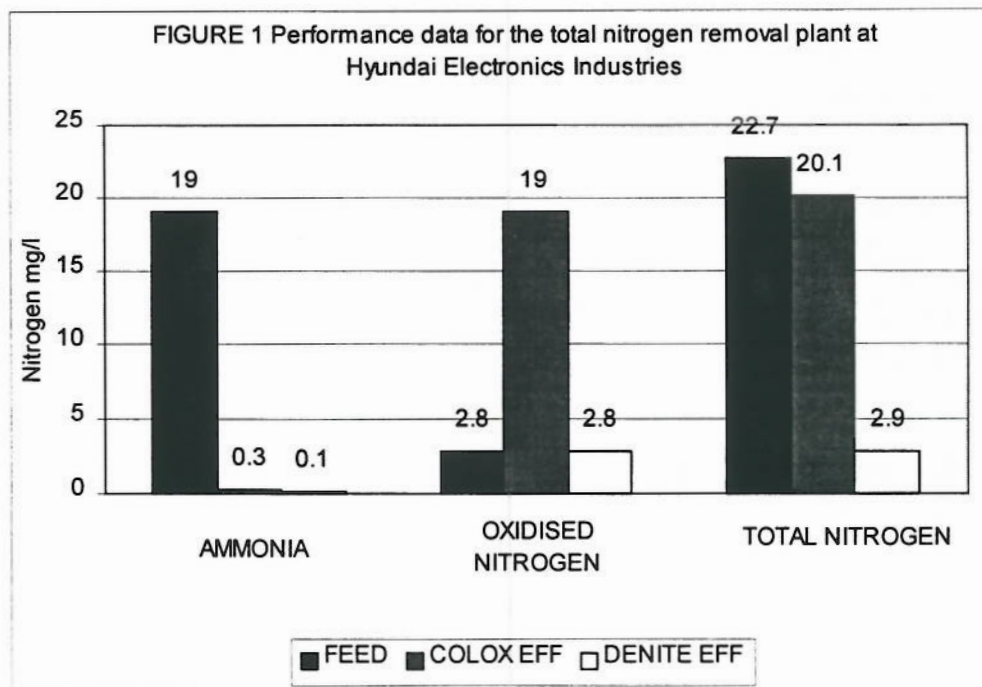
The semiconductor manufacturing plant for Hyundai Electronics Industries (HEI) at Ichon produces a wastewater with fluoride and ammonium contaminants. The fluoride is treated by a two-stage process using lime and lanthanide compounds respectively for each stage. Because the fluoride removal process removes virtually all of the available alkalinity it is necessary to add sodium carbonate to provide alkalinity for the subsequent nitrification step. The ammonia is removed by a two step process. First ammonia is oxidised by a ColOX™ BAF plant. The effluent from this is further treated by TETRA Denite® filters to remove oxidised nitrogen. In the denitrification step, methanol is added as carbon source.

The biological system consists of the following;

4 No ColOX™reactors each 13.7m long by 2.9m wide filled with 4m of 2mm rounded silica sand and support gravels.

3 No Denite® filters each 13.7m long by 2.9m wide also filled with 2mm rounded silica sand .In these filters the media depth is 1.8m of sand and 0.45m of graded gravel.

The plant is designed to treat a flow of 16000m³/d .The system was successfully started up in June 1997.As shown in figure 1 the system has achieved 99.5% nitrification and 90.7% total nitrogen removal.



7. Plastic manufacturing Plant Wastewaters at Formosa Plastics Plants at Jen-Wu and Lin Yuan Taiwan

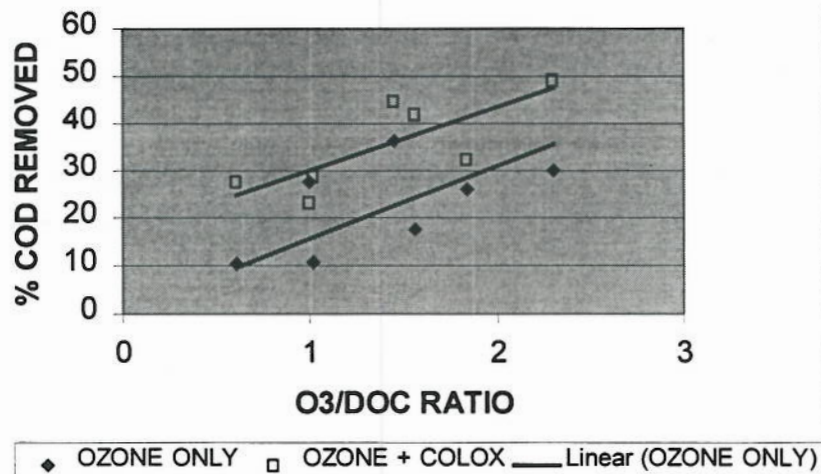
Since 1998 the effluent COD limitation for most point source discharges in Taiwan will be set at a maximum of 100 mg/l. Formosa plastics .At their plant at Jen-Wu, Kachsiung, Taiwan the raw effluent is derived from the vinyl chloride monomer and the chloro-fluoro carbon process units. This effluent is treated in an activated sludge plant. However, this plant can only produce an effluent with a COD of 150 to 180 mg/l.

Pilot trials with ozone showed that the required reduction could not be achieved with ozonation alone .Use of ozone followed by a ColOX™ BAF gave the required COD removals. Results of pilot trials are shown in figure 2

The results show that ozone treatment alone gives variable results and is not able to achieve the required COD removals. The combination of ozone with BAF is able to achieve better than the 33% required.

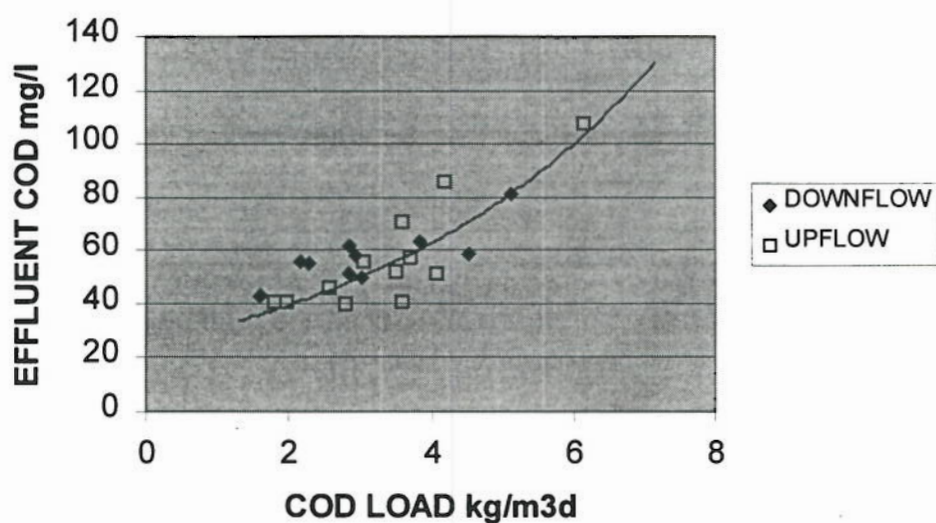
The full-scale plant is designed to treat 5000 m³/d. The ozonation process has a capacity of adding 6kg/h of ozone to the wastewater. The ozone plant is followed by 6 No circular ColOX™ reactors each 3.8m dia and containing 4m of media and support gravels. The plant is due for commissioning in April 1999.

**FIGURE 2 COD REMOVAL BY OZONE
WITH AND WITHOUT COLOX**



A similar plant has been built at the Formosa Plastics Plant at Lin-Yuan in Taiwan. During pilot studies for this plant a comparison of operation in both upflow and downflow modes was carried out. Results are shown in figure 3.

**FIGURE3 FORMOSA PLASTICS COLOX PILOT
TRIAL, COMPARISON OF UPFLOW AND
DOWNFLOW OPERATION**



These results show very little difference in effluent COD between the two modes of operation.

The full-scale plant consists of five ColOX™ reactors to reduce COD from 160 mg/l to less than 90 mg/l. This plant is designed to treat 6545m³/d of effluent. The cells are rectangular 2.9m wide, 7.7m long and contain 4 m of media and gravel.

In addition, 3 No TETRA deep bed filters have been provided to treat a total flow of up to 11000m³/d. This flow includes effluent from other treatment processes. There are three filters each 2.9m by 7.7m containing 1.8m of high specification silica sand media. There is no ozone treatment in this plant

The plant was commissioned in August 1998. The start-up data showed that on average COD was reduced from 122mg/l to 42mg/l (65%) and TSS was reduced from 42 mg/l to 6 mg/l (86%).

8. Conclusions

Biological aerated filters are now accepted as a reliable process for treatment of sewage, particularly where a small footprint plant is required.

In this paper we have described application of this technology to treatment of a wide variety of industrial effluents. As well as use for conventional biological oxidation, the process can be combined with anoxic filters to achieve a high degree of nitrogen removal. When combined with ozone oxidation the process can be used to achieve removal of "hard" COD.

Overall, BAF's have even more potential for industrial effluent treatment than for sewage treatment.

