Cranfield UNIVERSITY

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

Recent Experience and Developments Using the Biopur BAF Process

S Clarke Trafalgar House Water Projects

Introduction

Biological processes have been used to treat waste waters for many years in order to improve public health, remove offensive odours and to reduce pollution in the receiving watercourse.

In the 1980's public concern led to UK and European legislation to further improve the treatment required of sewage prior to passing to a watercourse. This legislation is now embodied in the UK Bathing Water Directive and the Urban Waste Water Treatment Directive. This has lead to the improvement of sewerage and the reduction of the number of sewage discharges, as more sewers are now being fed to sewage treatment works. Sewage works have therefore often become overloaded and now require to be upgraded in order to meet these legislative requirements. In some cases completely new sewage treatment works have been required.

Development of sewage treatment works is often in already built up areas where land can be often restricted. This combination of a sizeable market with technical constraints such as available land, odour control requirements and noise restriction has encouraged major innovation and development of sewage treatment processes to provide cost effective solutions using new technology.

One such innovative process is the Biological Aerated Filter (BAF) of which many systems are now available on the market and well over 100 plants are currently operated worldwide, treating both industrial and domestic waste water for carbonaceous pollutant, ammonia or complete nitrogen removal.

One innovative system that is now proving popular for treating wastewaters is the Sulzer Biopur biological aerated filter. This uses a submerged structured packing rather than the more common granular forms, which leads to a number of advantages for operating companies.

This paper presents a brief description of the Biopur BAF process, its key operating features, and three case studies using the Biopur process for wastewater treatment in the UK.

BAF Processes

BAFs are fixed film reactors that combine biological treatment with suspended solids retention in a single process unit, thus eliminating the requirement for a secondary clarifier. Biomass is retained on a media that is submerged in the sewage being treated, whilst oxygen used for biological activity is supplied from air blowers via diffusers or nozzles located at the base of the BAF. Excess biomass is removed by periodic backwashing of the media. BAFs are characterised by a common set of components including the media type, aeration system, backwashing system and the process configuration.

There are a number of proprietary BAF systems available today each of which use a particular media. Most of these are granular such as sand, pumice stone, expanded clay expanded slate or polystyrene beads. An alternative successful biomass support is a structured plastic packing used in the Biopur System. The spontaneous attachment of microorganisms to plastic surfaces is not new. Indeed, it has been successfully applied to several biological wastewater treatment processes, rotating biological contactors and trickling filters. However, its potential as biomass support media for submerged aerated filters was only realised in 1982.

The Biopur System

During the early 1980's Sulzer Brothers A.G. GmbH Switzerland developed and installed a commercial sized structured packing variation of the BAF system [1]. The excess biomass and retained solids are removed by periodic air and water backwashing as with granular media BAF, eliminating the need for secondary clarification. In practise the process can be maintained for several days between consecutive backwashing and no attrition or loss of media take place during the backwashing operation. This is obviously a considerable advantage over granular media type systems.

The unique use of structured packing in the Biopur system also leads to a number of other significant advantages [2, 3, 4].

- No media loss reduces operating cost and prevents contamination of the water course.
- No secondary clarification.
- Minimal head loss can allow easy installation in existing plants.
- Efficient process air control is possible as the partial back mixing of sewage in the Biopur unit leads to representative dissolved oxygen measurement. This in turn leads to a significant power economy.

- Good quality sludge with large easy to settle flocs is produced.
- Biopur can accept very high suspended solids concentrations, including screened/degritted sewage.
- Very high tolerance of toxic or bio-inhibitory substances due to the process configuration.
- Very small footprint as 4 m to 8 m deep media is commonly used.

Figure 1 shows some of the process options available using the Biopur system. A simple two stage process with both stages aerated is usually used for the removal of BOD, COD and suspended solids. If ammonia removal is required, then nitrifying organisms are encouraged by using a packing with a high surface area in the second stage to achieve, for example, 10 mg/l ammoniacal nitrogen in the treated waste water. If total nitrogen is to be removed, then the first stage can be operated under anoxic conditions with recycling of treated effluent from the second nitrifying stage. Phosphorus can be removed by adding iron or aluminium salts to precipitate phosphates. These can be removed by filtration using a tertiary filter or simply by adsorption onto the biofilm within the Biopur cell.

There is now significant design and operational experience with the Biopur system with a total of 14 plants operating or under construction (see Table 1).

In the UK there are five full scale Biopur plants in operation or under construction for treating domestic sewage. The Hayle installation is the largest BAF plant in the UK and is discussed below. The plants at Ilfracombe, Ashford and Salcombe are designed to produce secondary standard effluent to a consent standard of 25 mg BOD/l and 35 mg TSS/l both on a 95 percentile basis.

The most recent plant contract to be awarded is for the 300,000 pe Colne Bridge sewage treatment works in Huddersfield. This plant will remove BOD, suspended solids and ammonia and is a particularly interesting application as the wastewater can contain substances that inhibit nitrification which are found in industrial effluent discharges. The Biopur system, however, is extremely efficient in treating this kind of effluent due to the structured packing. Some of the biomass remains fixed during backwashing which allows subtly different microbial cultures to form at different sections of the biofilm across the height of the media. This gives optimum resistance of nitrifying organisms to toxins and removal of "hard" COD.

Case Study 1 Hayle Sewage Treatment Works

Hayle STW in Cornwall was uprated as part of South West Water's Clean Sweep programme to improve sewage treatment for Penzance, St Ives and Hayle catchments. The complete scheme comprised of collection and transportation of sewage from the catchment areas to the existing Hayle STW which required upgrading. Disposal of sewage is via a 2.8 km sea outfall to the Atlantic Ocean. The whole scheme was designed and constructed by Trafalgar House Water Projects and was the Civil Engineering winner in the 1995 British Construction Industry Awards.

Hayle STW required substantial new works including additional secondary treatment to supplement the existing biological trickling filters. The most cost effective solution was to install the Biopur process upstream of the splitter box for the trickling filters to give two stage biological treatment. Biopur requires only an exceptionally low driving head for operation and could therefore be located between the existing primary settlement tanks and trickling filters without a need for interstage pumping.

The Biopur plant was designed to remove BOD and suspended solids from primary settled sewage to a specification of 40/60 mg/l respectively. The plant comprises 8 single stage Biopur cells with a total footprint close to that of one of the existing three biological trickling filters, including the inlet and outlet channel, backwash tanks, pumps, control room and separate process and backwash air blowers. The plant treats sewage for 170,000 pe. including treatment up to formula A flowrate of 1851 l/s and an average flowrate of 429 l/s.

Figures 2 and 3 shows typical performance data for the Biopur unit which has exceeded expectations since commissioning in 1994. During the year long performance trials outlet BOD averaged 11-16 mg/l and suspended solids 15-29 mg/l corresponding to 60-90% reduction of BOD and 40-80% reduction of TSS.

Case Study 2 Nigg Bay STW

Most of Aberdeen's domestic sewage and a significant proportion of industrial effluent from paper mills and other industries are treated through Nigg Bay STW. Currently sewage passes through fine screens and degritters prior to discharge to the North Sea. This will be uprated to secondary treatment by the end of the year 2000 in order to comply with the Urban Waste Water Treatment Directive. A Slimpac Lamella and Biopur demonstration unit was installed and operated between April - September 1994, as shown in the flowsheet in Figure 4. The feed was of high strength and very variable in nature due to periodic discharge of industrial effluent. The demonstration plant feed also simulated the diurnal flow fluctuation in the main plant. Figures 5 and 6 show the plant's performance.

Monthly average removal efficiency of BOD and TSS was exceptionally high (eg. 93% BOD removal, 93% TSS removal and 82% COD removal in September 1994. Consent standards have not yet been defined for this site but the Biopur attained the expected 40 mg/l / 60 mg/l BOD/TSS specification, on a 95 percentile basis. The trial was supervised by an independent consultant, Halcrow Scotland, appointed by Grampian Regional Council.

Case Study 3 East Hull STW

It was originally considered that Hull needed to comply with the Urban Waste Water Treatment Directive (UWWTD) primary effluent standard of 20% BOD and 50% TSS removal. Due to the influence of trade discharges conventional chemical and physical treatment options were unable to produce the required quality of treated sewage. Consequently Yorkshire Water decided to investigate the use of biological treatment to achieve the desired pollutant reductions and invited Trafalgar House Water Projects to install the Biopur demonstration plant at East Hull Pumping Station.

Two Stage Biopur

The demonstration plant was initially installed at East Hull to treat 5mm screened raw sewage through two stages of Biopur as shown in Figure 7. The necessary BOD removal was achieved through the process as well as solids capture and biological conversion to comfortably achieve the required effluent quality as shown in Figure 8.

Single Stage Biopur followed by Settlement

Figure 9 illustrates the process alternative investigated at East Hull which comprised of a single stage Biopur followed by a conventional sedimentation stage. In this case Biopur provided the necessary BOD removal whilst converting previously unsettleable solids in the raw sewage to easily settleable humus type solids as seen in Figure 10.

Conclusions

BAF processes have amply demonstrated their capability to reliably achieve high quality effluent standards Their compact and modular construction makes them the ideal selection for sensitive sites and there is considerable experience with design, construction and operation of totally enclosed works.

The Biopur BAF process offers design and operational advantages particularly with respect to :-

- No loss of media.
- Low headloss.
- Greater aeration efficiency.

- Stability to hydraulic and load variability.
- Easily settled sludge.
- No risk of clogging.
- Excellent characteristics for treating toxic or bio inhibitory components.

Biopur is now proven both in the UK and Europe with a total of 14 reference plants being operated or under construction. Applications amply demonstrate that submerged structured media can be used for primary secondary and tertiary treatment, nitrification and denitrification as well as hard "COD" removal.

References

(1) Ryhiner G., Birou B., and Gross H. The Use of Submerged Structured Packings in Biofilm Reactors for Wastewater Treatment. Wat. Sci. Tech., 26(3) 723. 1992.

(2) Mittal R.D., Quickenden J., and Gros H., Efficient Nutrient Removal with Sulzer Biopur and Filtration Systems, Aqua Enviro Conference on 'Nutrient Removal from Wastewater' Wakefield, UK, 1992.

(3) Gros H., Biopur System and Bioactive Filters from Advanced Wastewater Treatment. Sulzer Technical Review 4/1991.

(4) Gray T.W., Biological Aerated Filters : The Solution to Small Footprint Plant, International Water and Environmental Engineer, Summer 1993.

TABLE 1 Reference List of Biopur Installations

Location	Size	Date of Commissioning
Geneva	6000 pe	1988
Sierre	65,000 pe	1994
Ciba Giegy Zurich	300 kg BOD/day	1991
Hayle	170,000 pe	1994
Val d'Anniviers	40,000 pe	Under Construction
Salcombe	10,000 pe	1995
Ilfracombe	26,000 pe	Under Construction
MKD Au Stem	750 pe	Landfill Leachate
Val de Ruz	20,000 pe	1997
Ashford	80,000 pe	Under Construction
Diecimo	23,000 pe	Pulp Wastewater
Tambrig	2,000 pe	Landfill Leachate
Hallvilersee	20,000 pe	Under Construction
Huddersfield	300,000 pe	Under Construction

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FIGURE 1 BIOPUR PROCESS OPTIONS

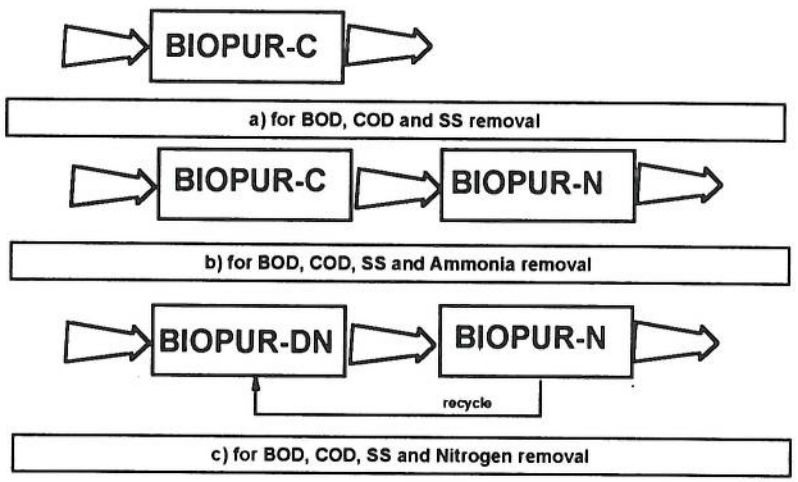

FIGURE 2 HAYLE STW- BIOPUR PLANT

TSS performance- Sep 1994 to Feb 1995

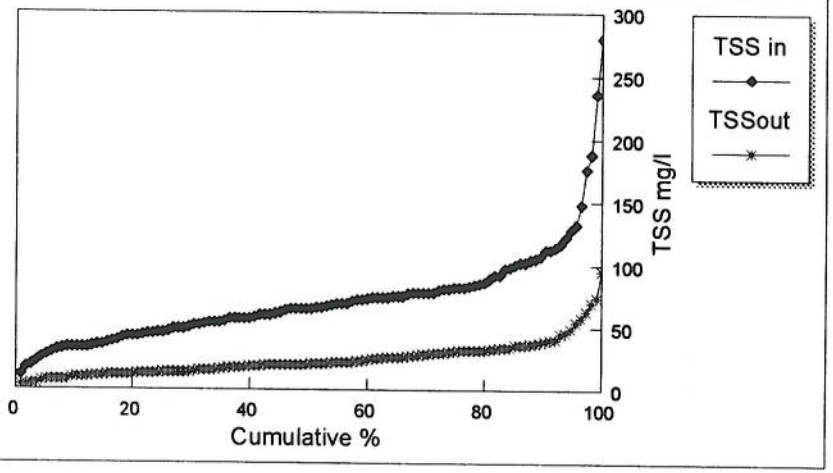

FIGURE 3 HAYLE STW- BIOPUR PLANT

BOD performance- Sep 1994 to Feb 1995

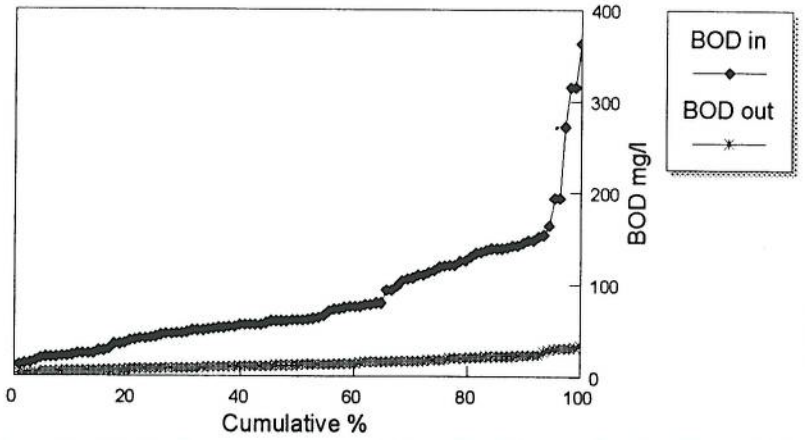

FIGURE 4 SLIMPAC LAMELLA AND BIOPUR DEMONSTRATION PLANT

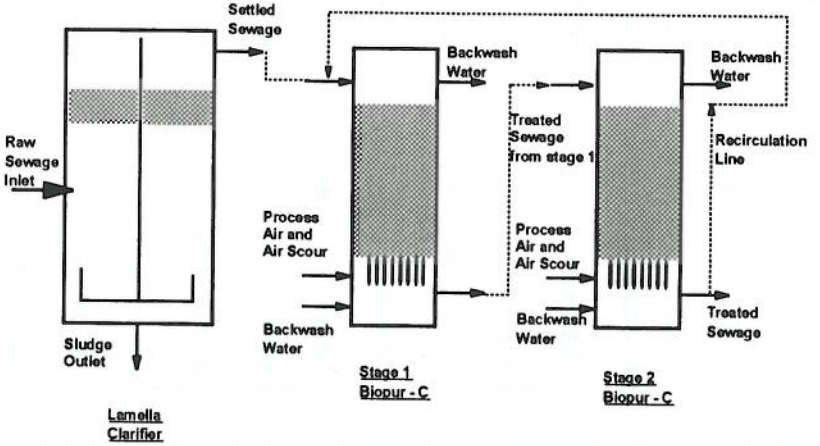

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FIGURE 5 BIOPUR DEMONSTRATION PLANT- NIGG BAY

TSS performance- June 1994

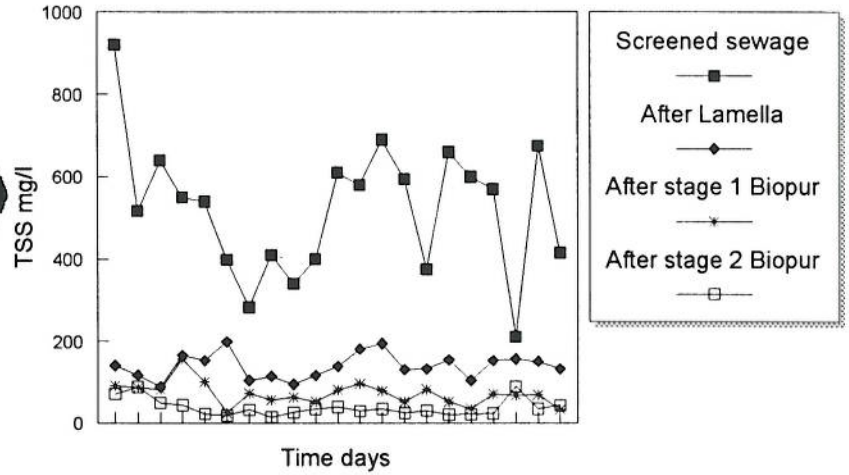


FIGURE 6 BIOPUR DEMONSTRATION PLANT- NIGG BAY

BOD performance -June 1994

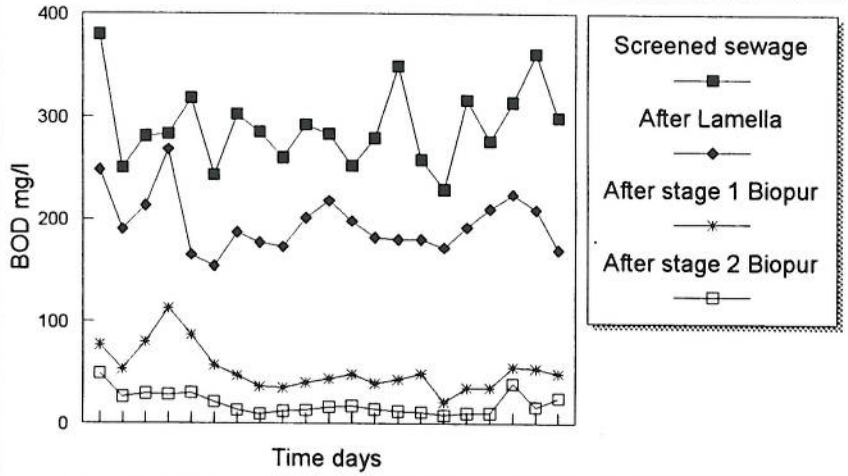


FIGURE 7 BIOPUR DEMONSTRATION PLANT HULL EAST

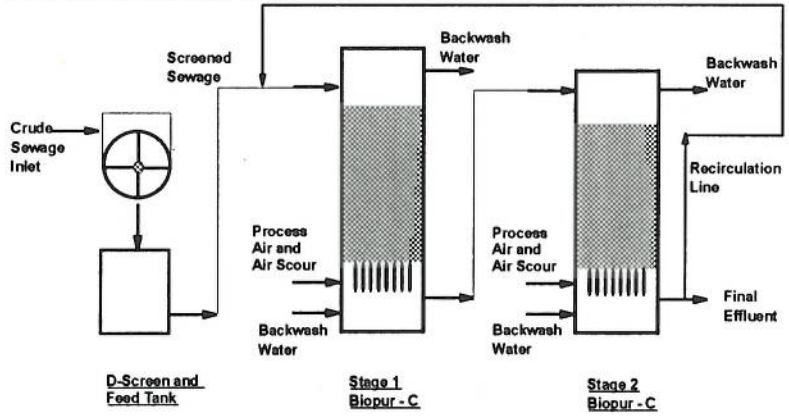


FIGURE 8 BIOPUR DEMONSTRATION PLANT- EAST HULL

TSS & BOD performance. Two stage Biopur

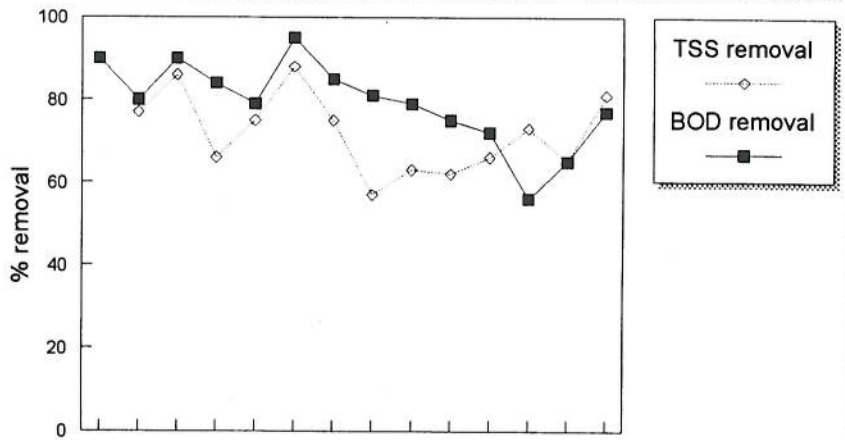


FIGURE 9 ALTERNATIVE BIOPUR SCHEME HULL EAST

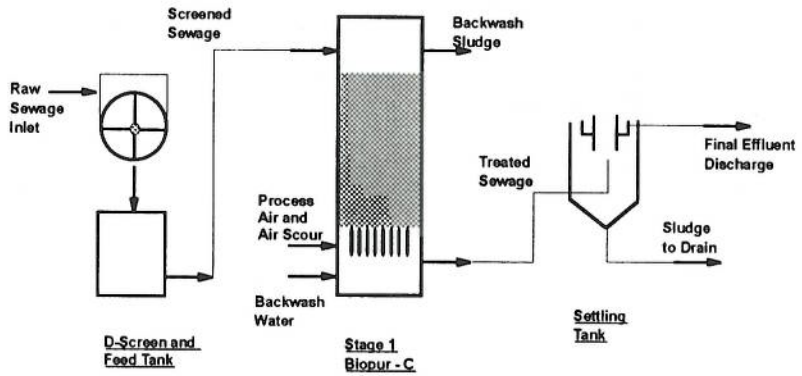
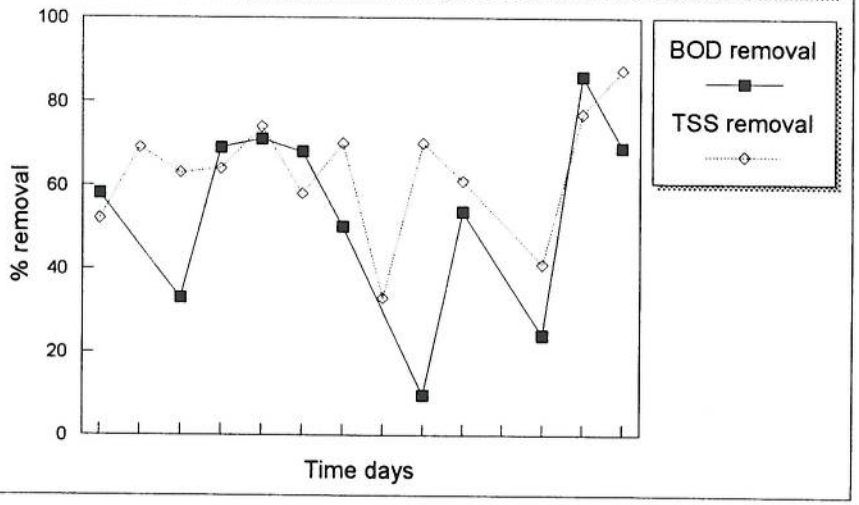


FIGURE 10 BIOPUR DEMONSTRATION PLANT- EAST HULL

TSS & BOD performance . Single stage Biopur plus sedimentation



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