

# EfloSAF Submerged Aerated Filter

## EfloSAF Benefits

- High Quality Final Effluent of 10/10/2 BOD/TSS/NH4 - N
- Very High MLVSS Concentration
- Attached Growth Technology
- High Tolerance of Shock & Over Loads
- Upgrade Existing Plants
- Nitrification Polishing
- Low Power Consumption
- Low Sludge Production
- Small foot print & high capacity
- Above or Below Ground
- Prefabricated Containerised

## General Description

**EfloSAF** is a fixed-bed bioreactor for 5 - 5000 m<sup>3</sup>/day using "Attached Growth" technology by means of a submerged, aerated, high surface area media.

The 'heart' of the system is a structured matrix of welded and rigid polypropylene media with a very high specific surface area. This allows for high concentrations of attached biomass to be maintained in the Biozone.

The unique flow patterns within the media ensure high rates of biological oxidation with relatively low retention time. The media ensures air bubble retention is prolonged and allows for exceptionally high oxygen transfer rates with low energy consumption.

There are few moving parts within the plant allowing for low maintenance and low operator demands.

The **EfloSAF** is well proven over decades, with reliable, robust and trouble free operation.

Due to the gentle but fully mixed environment within the Biozone, the biomass is allowed to grow to a long sludge age before being "sloughed" from the media. This produces excellent effluent with good nitrification, partial de-nitrification and low levels of waste sludge production.

**EfloSAF** plants are either pre fabricated steel, package containerised or use insitu concrete tanks for larger plants. Existing treatment plants can be upgraded for capacity and effluent quality by adopting **FBBR technology**.

## Eflo - About Us

**Eflo International Ltd, UK** is an OEM company offering proven and robust technologies for advanced wastewater treatment systems for both domestic and industrial waste water.

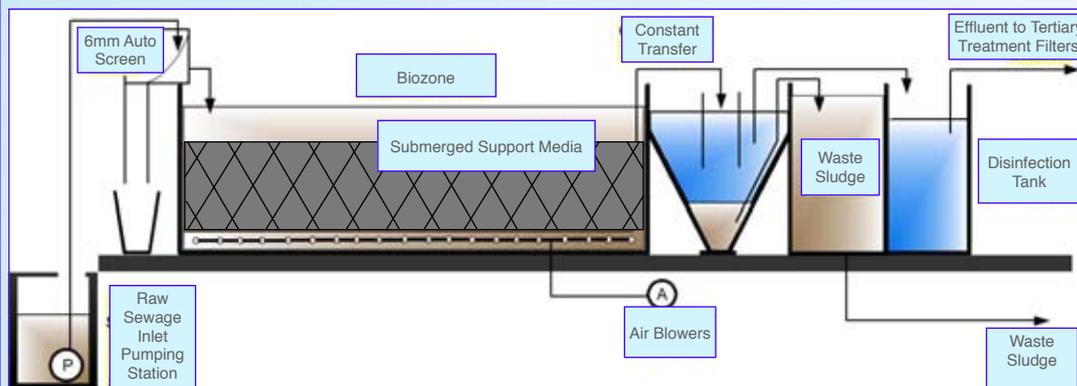
Eflo also designs and manufactures reverse osmosis plants for sea water and brackish water desalination delivering these as ready to run packaged plants in either skid for or containerised.

**Eflo** has designed & installed treatment plants in Europe, the Middle East, Africa, Caribbean the Indian Ocean islands over a period of more than 40 years and can delivery globally through local agents who provide product support.

**Eflo** offers a range of other innovative water treatment products including oily water separation and DAF processes as well as water treatment chemicals

Please contact us so we can help you with your water treatment requirements.

**EfloSAF Package Sewage Treatment Plant 2000 m<sup>3</sup>/day**



### Eflo Water Treatment Products :

- EfloSAF** Submerged Aerated Filter
- EfloMBR** Membrane Bio-Reactor
- EfloDAF** Dissolved Air Floatation
- EfloGREY** Grey Water Re-Cycling
- EfloRO** Sea Water & Brackish Water Reverse Osmosis
- EfloSBR** Sequential Batch Reactor
- EfloCT** Extended Aeration
- EfloSEP** Oily Water Separator
- EfloCHEM** Water Treatment Chemicals
- EfloSLUDGE-DRY** Sludge Dewatering

# EfloSAF Submerged Aerated Filter

## Standardised and Containerised EfloSAF Treatment Plants

EfloSAF plants can range in capacity from 5 - 5000 cubic meters per day. These can be generally prefabricated packages, factory tested and shipped ready to work subject to some local civil works including the inlet pumping station and some pipe. There is no reason why they cannot be made larger using concrete tanks or circular, bolted-panel tanks, however, at the larger sizes, economics generally dictate alternative technologies such as the EfloMBR Membrane Bioreactor or the EfloSBR Sequential Batch Reactor.

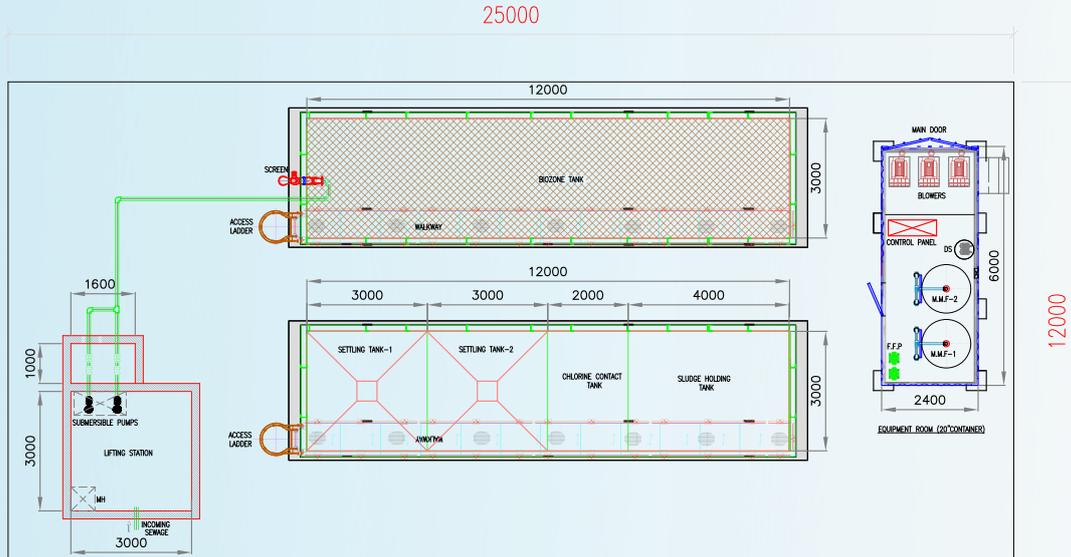
For global export customers, Eflo offer the standardised and containerised EfloSAF plant to minimise transport costs. As expected, these EfloSAF plants are based around the exact dimensions of a Hi Cube ISO container, either 6m or 12m. The table below gives the range of plants at given capacities. These plants can be deployed singularly or in multiple parallel lanes to meet the required capacity. If multiple plants are used, Eflo will provide bespoke builder's works drawings to show common items, such as a pumping station.

Model	Daily Flow cubic meters	Peak Flow m <sup>3</sup> per hour	Inlet BOD mg/l	Inlet Suspended Solids (SS) mg/l	Inlet Ammonia NH <sub>4</sub> mg/l	Treated Effluent BOD mg/l	Treated Effluent SS mg/l	Treated Effluent Ammonia NH <sub>4</sub> mg/l	Installed Power KW	Absorbed Power KW
EfloSAF 20 - ECS	20	3	300	300	30	10	10	10	6	3
EfloSAF 50 - ECS	50	3	300	300	30	10	10	10	8	4
EfloSAF 100 - ECS	100	3	300	300	30	10	10	10	12	5
EfloSAF 150 - ECS	150	3	300	300	30	10	10	10	16	7
EfloSAF 200 - ECS	200	3	300	300	30	10	10	10	18	8
EfloSAF 250 - ECS	250	3	300	300	30	10	10	10	22	9
EfloSAF 300 - ECS	300	3	300	300	30	10	10	10	32	14
EfloSAF 350 - ECS	350	3	300	300	30	10	10	10	36	16
EfloSAF 500 - ECS	500	3	300	300	30	10	10	10	40	17
EfloSAF 1000 - ECS	1000	3	300	300	30	10	10	10	84	38

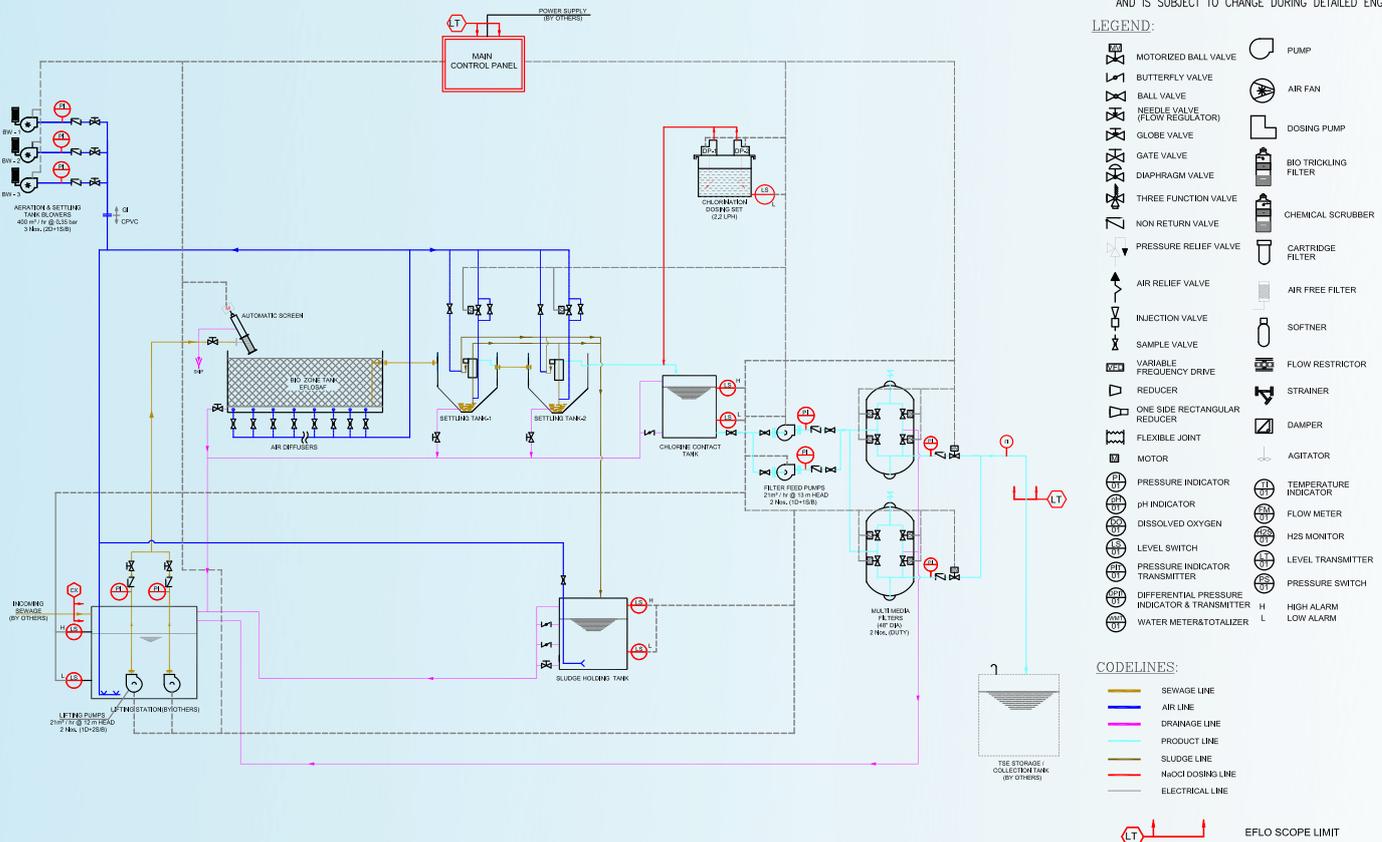


# EfloSAF Submerged Aerated Filter

## EfloSAF 500 - ECS 500m<sup>3</sup> per Day - Plant General Arrangement



## EfloSAF 500 - ECS 500m<sup>3</sup> per Day - Process Flow Diagram



**EFLO**

Eflo International Ltd, UK

OEM Water and Waste Water Treatment Technologies

# Eflo SAF

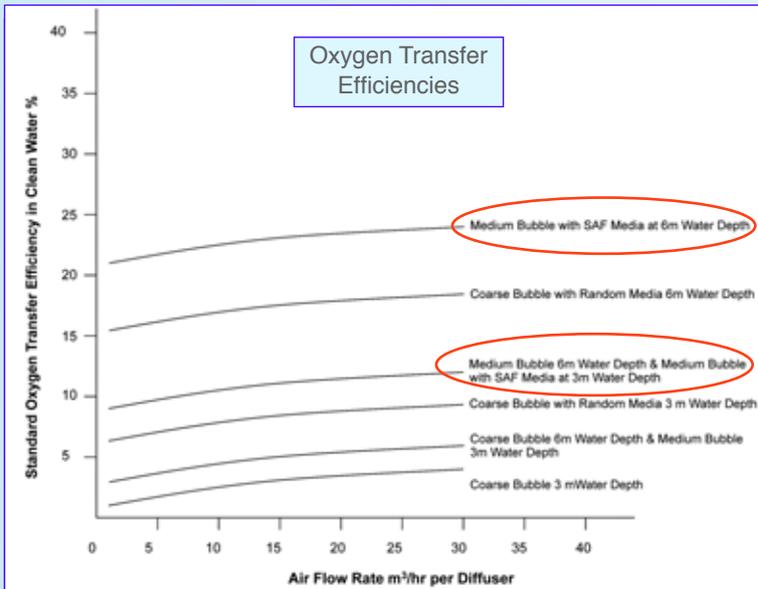
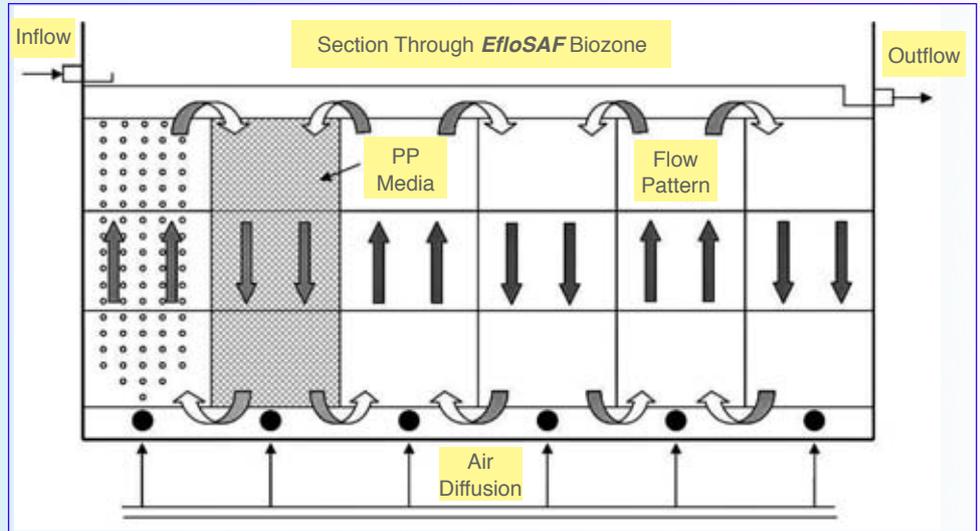
# Submerged Aerated Filter

## EfloSAF Flow Pattern in the Biozone

The flow can be considered, fully mixed due to the "airlift" effect. With only the minimum air required for oxygen transfer, the water fully circulates the entire biomass support media. The support media is in effect a multitude of "zig zagging" tubes. With the specific spacing of the air diffusers below the media, the "airlift" effect lifts the flow in alternates sections of the media. In the other sections, the flow falls by gravity. The flow of water follows the same pattern as the air bubbles, ensuring a long period in contact with the attached biomass. The entire process is without short circuiting.

The same "airlift" circulation provide the necessary scouring to assist with biomass sloughing.

The water within the Biozone is pre screened to 6mm eliminating any chance of blockage of the matrix. Further, the biomass only grows to 1 or 2 mm before being sloughed. The matrix voids are around 25 mm dia.



EfloSAF Modules, being craned into an existing treatment works to improve capacity and effluent quality. Multiple modules can be used, side by side and stacked upon each other to provide the correct volume of biomass support media.

The installation is rapid with minimal down time for the treatment plant. New air blowers and process controls are also added.



EfloSAF showing the biomass support media. The pre fabricated modules are rapidly positioned adjacent to one another and fixed together.

# Eflo SAF

# Submerged Aerated Filter



**EfloSAF 2000 m<sup>3</sup>.day**

Atlantis Hotel, The Palm, Dubai.



**EfloSAF Containerised**



**EfloSAF for Ammonia Reduction.**

Rusper WWTP, Thames Water, UK. Treatment of TSE with 30 mg/l NH<sub>3</sub>-N to < 3 mg/l.



**EfloSAF 100 m<sup>3</sup>.day.**

One of several plants supplied to the African Union Commission in Sudan for the Ceasefire Commission, Darfur, Sudan.

Factory built, tested, commissioned and shipped for quick start up in the humanitarian camps



**EfloSAF for International City, Dubai.** 1000 m<sup>3</sup>/d. TSE < 10 mg/l BOD, SS < 10 mg/l, HN<sub>3</sub>-N < 5 mg/l



**EfloSAF for Ministry of Public Works Kuwait.** 300 m<sup>3</sup>/d. TSE < 10 mg/l BOD, SS < 10 mg/l, HN<sub>3</sub>-N < 5 mg/l

**EFLO**

Eflo International Ltd, UK

OEM Water and Waste Water Treatment Technologies

## **EfloSAF Fixed Bed Support Media, MLVSS and Process**

The **EfloSAF** operates with a retention time of between 4 - 6 hours in the Biozone. This demands a very high concentration of biomass ("equivalent" MLVSS) to be embedded and fixed in the bioreactor. The biomass is delicate and must be provided with a gentle environment to thrive. The **EfloSAF** provides just these conditions.

The "Sloughing" diagram shows how the biomass can grow fully to a thickness whereby an anaerobic layer is formed at the surface of the support media. The "sloughed" biomass is further assisted by the action of the aeration bubbles passing over the surface of the biomass. This "sloughed" biomass is collected in the settlement tank, where it settles very easily. Because the biomass is correctly fixed in the biozone, sludge return ( or RAS as in an activated sludge plant) pumping is not required in the **EfloSAF** - thus eliminating a major operator task.

Because the **EfloSAF** is an advanced version of a conventional fixed bed bioreactor, such as a trickling filter, it still utilises conventional settlement tanks for clarification. With such a high MLVSS concentration in the bioreactor, it is critical that the active biomass remains attached to the support media. The "sloughed" biomass, as described below, is carried to the settlement tanks where it is captured and disposed of to the sludge consolidation tank. The **EfloSAF** process ensures the "sloughed" biomass in suspension does not exceed 3000 mg/l limit for good settlement. This is achieved by gentle air scouring, the naturally occurring nitrogen bubbles of the de-nitrification and running the sludge age to a point where sticky polysaccharide "glue" is removed.

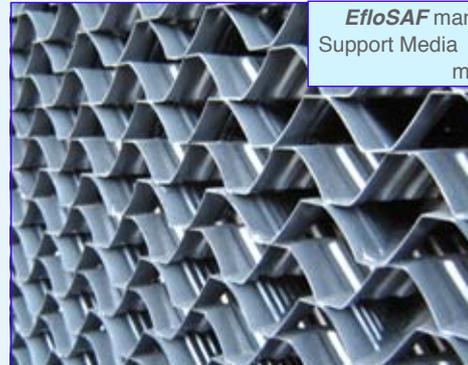
As well as delivering a fully nitrified effluent, the long sludge age in the **EfloSAF** and the ability to retain the biomass fixed in the bioreactor, also delivers partial de-nitrification as well as very low sludge production.

The **EfloSAF** uses Medium Bubble air diffusers. These are located at specific points below the biomass support media. The presence of the media above the air diffusers provides exceptionally good oxygen transfer efficiencies, in line with the best fine bubble air diffusers. The support media allows for long bubble retention times due to the "zig zag" route through the media. The high oxygen transfer efficiency reduces the size of the air blowers and with large power savings.

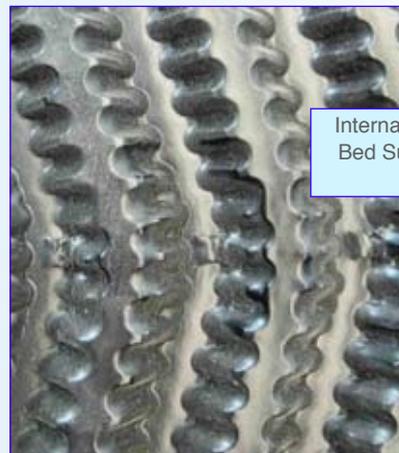
Other fixed film processes are available, such as the moving bed bioreactor (MBBR). Unlike the **EfloSAF**, this is a derivative of "suspended growth" or activated sludge process. In the MBBR, "random media" is used to partially fill the aeration tank and provide the necessary surfaces for the biomass to attach too. Unlike, the **EfloSAF**, ONLY coarse bubble aeration can be used as complete mixing of the aeration tank is essential. Not only is this very energy hungry but this causes excessively aggressive mixing which disrupts the proper growth of the biomass, causing it to detach too early and remain in suspension.

Like the **EfloSAF**, the MBBR demands a very high MLVSS concentration to achieve the short retention time, however, due to the aggressive aeration disrupting the growth of biomass on the media, the biomass is mostly found to be in suspension with only a minority being attached to the random media. This suspended biomass has concentrations far in excess of the design limits for humus settlement tanks, hence these become overloaded with solids which pass out of the plant with the effluent. This then overloads the tertiary treatment equipment which suffer excessive backwash cycles. The loss of biomass from the MBBR bioreactor is partly cured by the use of return activated sludge (RAS) pumping - adding a complication for the operator as the process no longer works as a "single pass" as in the **EfloSAF**.

Eflo are OEM engineers with 40 years of experience in waste water treatment. 15 years of designing and manufacturing **EfloSAF** plants has proven time and time again that a "fixed bed bioreactor" is the most reliable and efficient attached growth process available.



**EfloSAF** manufactured Biomass Support Media 150 m<sup>2</sup> per m<sup>3</sup> & 240 m<sup>2</sup> per m<sup>3</sup>



Internal view of the **EfloSAF** Fixed Bed Support Media Showing "Zig Zag" Pattern



In House Manufacturing of the EfloSAF support media

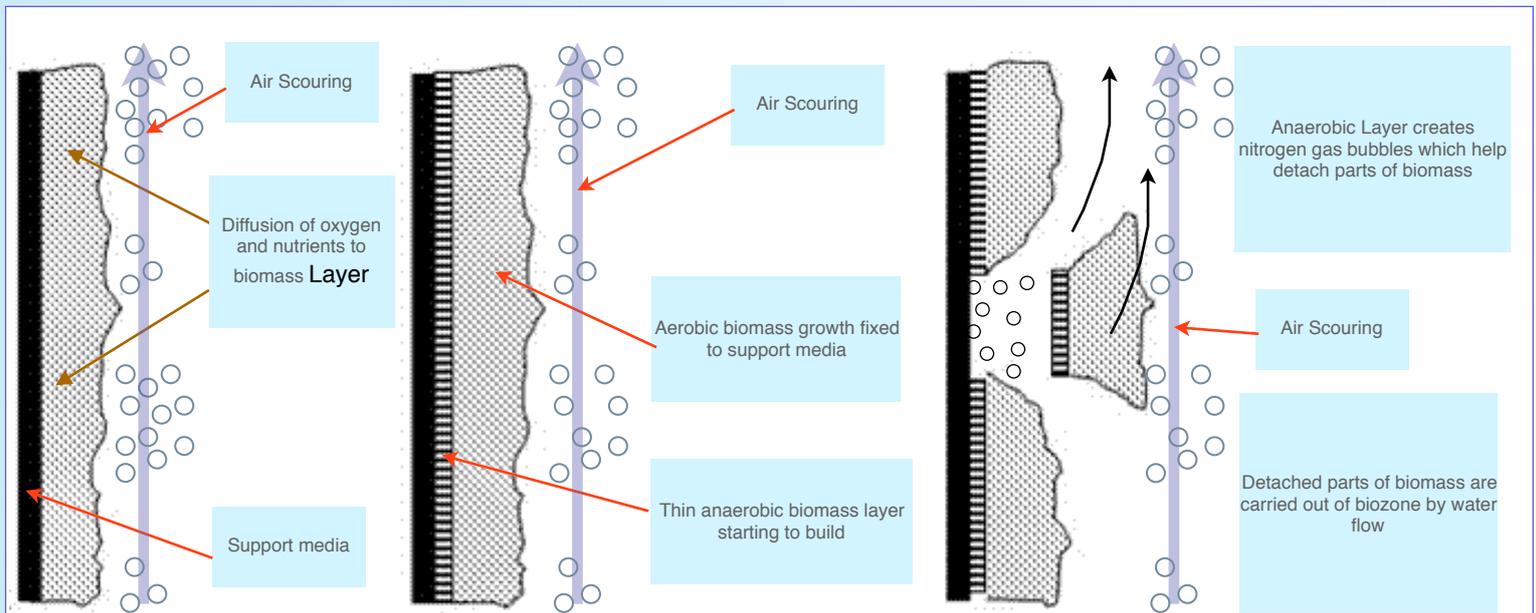


In stock EfloSAF media for immediate availability and short delivery time orders

The EfloSAF media, which performs the task of 'fixing' the biomass in the Biozone, is the 'fixed bed' part of the bioreactor.

The support media performs a critical, multi-functional task :

1. It provides a very benign and attractive place for the biomass to grow to very high concentrations
2. It provides extremely high contact areas between the liquid and the biomass and long contact times
3. It delivers long air bubble retention times for high oxygen transfer efficiency
4. It shears the air bubbles emerging from the medium bubble air diffusers delivering oxygen transfer efficiencies close to fine bubble type for reduced power consumption
5. It allows the biomass to remain in the reactor for full nitrification and partial de-nitrification without anoxic steps or mixed liquor re-circulation.



**EfloSAF** Biomass "Sloughing" Process

## EfloSAF

### Biomass "Sloughing, Nitrification & Partial De Nitrification"

This is a continuous process of biomass growth, followed biomass detachment. The detachment occurs shortly after a thin anaerobic layer forms at the support media surface. This anaerobic layer forms when the biomass thickness prevent air diffusing the full depth of biomass. The polysaccharides firmly "gluing" the biomass to the media reduce and the nitrogen bubbles, along with the aeration scouring, "slough" chunks of biomass from the media surface. New biomass rapidly grows in the place of the detached biomass and the process continues.

Therefore, biological oxidation drives treatment to full nitrification with some partial de-nitrification occurring deep inside the biomass, close to the support media.

This excellent treatment capacity is achieved without the requirement for Anoxic Zones or with the requirement for Mixed Liquor Recirculation. All of which makes the process very easy.

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## EfloSAF Performance & Efficiency

Below are Inlet and Outlet results from an EfloSAF operating at the Atlantis Hotel, Palm Jumeirah, Dubai. The plant is designed for full nitrification with minimum ammonia  $\text{NH}_3 - \text{N}$  in the final effluent as well as a final effluent BOD of  $< 10 \text{ mg/l}$ . The final effluent is used for 'restricted' irrigation of the landscaping via drip irrigation, so, the ammonia in the irrigation water must be minimised to prevent smell. Of course, the nitrate is a useful plant nutrient and therefore the plant is not designed for de-nitrification, however, the results demonstrate that this EfloSAF is achieving a significant amount of de-nitrification.

As is typical of the region, the raw sewage is quite weak and this can be seen in the Influent analysis.

"AHSL, Dubai is accredited by DAC for the tests below."

PARAMETERS	TEST METHODS	UNITS	DETECTION LIMITS	RESULTS
pH at 25°C	APHA 4500 - H <sup>+</sup> B	---	0.01	6.26
Total Suspended Solids (TSS)	APHA 2540 - D	mg/L	5.0	113
Total Dissolved Solids (TDS)	APHA 2540 - C	mg/L	10.0	1648
Oil & Grease	APHA 5520 - B	mg/L	5.0	5
Chemical Oxygen Demand (COD)	APHA 5220 - B	mg/L	5.0	320
Biochemical Oxygen Demand (BOD) (5 days @ 20°C)	APHA 5210 - B	mg/L	2.0	152

"AHSL is not accredited by DAC for the tests below."

PARAMETERS	TEST METHODS	UNITS	RESULTS
Ammonia Nitrogen ( $\text{NH}_3 - \text{N}$ )	HACH 8038	mg/L	31.3
Nitrate ( $\text{NO}_3^-$ )	HACH 8171	mg/L	3.6

Remarks: None  
Test method variation: None  
Results relates only to the delivered items tested (if sampling was not carried out by the testing laboratory).  
Report shall not be reproduced (except in full) without written approval of the laboratory.

Anoop K. Mony  
Head of Chemistry Department  
Form:CHEM/WF/03 Rev.3

O. Mathew, Laboratories Manager  
For Al Hoty Stanger Laboratories

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Report date: 14/03/12

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Raw Sewage Influent Analysis  
EfloSAF  
Atlantis Hotel, Palm Jumeirah, Dubai

"AHSL, Dubai is accredited by DAC for the tests below."

PARAMETERS	TEST METHODS	UNITS	DETECTION LIMITS	RESULTS
pH at 25°C	APHA 4500 - H <sup>+</sup> B	---	0.01	8.44
Total Suspended Solids (TSS)	APHA 2540 - D	mg/L	5.0	< 5
Total Dissolved Solids (TDS)	APHA 2540 - C	mg/L	10.0	1312
Oil & Grease	APHA 5520 - B	mg/L	5.0	< 5
Chemical Oxygen Demand (COD)	APHA 5220 - B	mg/L	5.0	35
Biochemical Oxygen Demand (BOD) (5 days @ 20°C)	APHA 5210 - B	mg/L	2.0	4

"AHSL is not accredited by DAC for the tests below."

PARAMETERS	TEST METHODS	UNITS	RESULTS
Ammonia Nitrogen ( $\text{NH}_3 - \text{N}$ )	HACH 8038	mg/L	0.05
Nitrate ( $\text{NO}_3^-$ )	HACH 8171	mg/L	39.8

Remarks: None  
Test method variation: None  
Results relates only to the delivered items tested (if sampling was not carried out by the testing laboratory).  
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Anoop K. Mony  
Head of Chemistry Department  
Form:CHEM/WF/03 Rev.3

O. Mathew, Laboratories Manager  
For Al Hoty Stanger Laboratories

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Report date: 14/03/12

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Final Effluent Analysis  
EfloSAF  
Atlantis Hotel, Palm Jumeirah, Dubai

By molar mass calculations it can be seen:

Influent nitrogen is  $31.3 \text{ mg/l}$  as  $\text{NH}_3 - \text{N}$  plus  $3.6 \times 14 (\text{N}) / 62 (\text{NO}_3) = 32.10 \text{ mg/l}$  ( approx.)  
Effluent nitrogen is  $0.05 \text{ mg/l}$  as  $\text{NH}_3 - \text{N}$  plus  $39.8 \times 14 (\text{N}) / 62 (\text{NO}_3) = 9.04 \text{ mg/l}$  (approx.)

Therefore, the Ammonia nitrogen removal is 99.8% and the Nitrogen removal is 71.8%.

The BOD removal is  $> 97 \%$ .

## De-Nitrification

Although not required for an effluent to be used for landscape irrigation, it is sometimes required to reduce the Nitrate Nitrogen to very low levels of around  $5 \text{ mg/l}$ . This requires a plant to first Nitrify the ammonia to Nitrate and then de-nitrify to release the nitrogen as a gas to the atmosphere. Eflo have now designed, built and operate their EfloSNAF plant. The SNAF refers to a Submerged, Non-Aerated Filter. It uses all of the same high efficiency technology in the EfloSAF described here but is able to produce very low levels of Nitrate nitrogen, allowing the treated water to be used in lakes and landscaping water features without the causing algae growth problems.

**EFLO**

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