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**

**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 m3/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**

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EfloSAF plants can range in capacity from 5 - 5000 cubic meters per day. These can are 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.

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<tr>
<th>Model</th>
<th>Daily Flow cubic meters</th>
<th>Peak Flow m³ per hour</th>
<th>Inlet BOD mg/l</th>
<th>Inlet Suspended Solids (SS) mg/l</th>
<th>Inlet Ammonia NH₄ mg/l</th>
<th>Treated Effluent BOD mg/l</th>
<th>Treated Effluent SS mg/l</th>
<th>Treated Effluent Ammonia NH₄ mg/l</th>
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EfloSAF 500 - ECS 500m³ per Day - Plant General Arrangement

EfloSAF 500 - ECS 500m³ per Day - Process Flow Diagram
**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.**

**EfloSAF modules using stainless steel frames complete with air diffusion equipment for the upgrading of existing tanks.**
Eflo SAF Submerged Aerated Filter

Eflo SAF for International City, Dubai. 1000 m³/d. TSE < 10 mg/l BOD, SS < 10 mg/l, HN3-N < 5 mg/l.

Eflo SAF for Ministry of Public Works Kuwait. 300 m³/d. TSE < 10 mg/l BOD, SS < 10 mg/l, HN3-N < 5 mg/l.

Eflo SAF for Ammonia Reduction. Rusper WWTP, Thames Water, UK. Treatment of TSE with 30 mg/l NH₃-N to < 3 mg/l.

Eflo SAF for International City, Dubai. 2000 m³/day. Atlantis Hotel, The Palm, Dubai.

Eflo SAF Containerised 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.
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, 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.
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 NH₃ - N in the final effluent as well as a final effluent BOD of < 10 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 if 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.

By molar mass calculations it can be seen:

Influent nitrogen is 31.3 mg/l as NH₃ - N plus 3.6 x 14 (N) / 62 (NO₃) = 32.10 mg/l (approx.)

Effluent nitrogen is 0.05 mg/l as NH₃ - N plus 39.8 x 14 (N) / 62 (NO₃) = 9.04 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 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 EflosNAP 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.