COMBINING THE USE OF ENGINEERED AND NATURAL PLANTS IN ACTIVATED SLUDGE SYSTEMS

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ABSTRACT

Integrated Fixed Film Activated Sludge Plants (IFAS) rely on the use of a media on which a biofilm is grown, which results in a compact footprint as a majority of the biomass is fixed to a high surface area as opposed to being suspended.

A recent development of this process has been to combine naturally occurring plants with engineered media. To put simply, a botanical garden is placed on top of the IFAS reactors, with the plant roots penetrating into the reactors.

The interaction of enzymes and various organic acids from the plant roots to the bio-media creates a diverse biology, leading to increased process stability, less sludge production and lower energy demand when compared to conventional activated sludge plants. And the sewage treatment plant looks like a botanical garden.

Large scale installations in Europe have been in operation for 5 years. This presentation discusses the design, operating and performance data of a 500,000 and 5,500 EP treatment plant using this process.

1.0 INTRODUCTION

Over the last few decades the drive for water reuse, nutrient removal and reduced footprint has seen the development of a number of different technologies for wastewater treatment. Many of these focus on the use of membrane technology as the phase separation step, such as Membrane Bio-Reactors (MBR).

In this paper a bio-film based process technology is discussed. Bio-film technology in wastewater treatment has been available since the 1970's, available as moving bed biofilm reactor (MBBR) systems or integrated fixed film activated sludge processes (IFAS). In general the bulk of the developments in this field relates to increased surface area, scouring and bio-film growth.

Generally the media used in either MBBR or IFAS is a non metallic surface. Both systems provide benefits such as reduced reactor size, high total available biomass inventory, high tolerance against biomass washout during storm events and simultaneous nitrification-denifrication within the biofilm layer.

The biofilm technology discussed in this paper is known as an Organica Food Chain Reactor (FCR). This process combines the use of naturally occuring plants, such as bulrushes, marsh reeds, together with an IFAS based process. A greenhouse is typically used to house the process, resulting in an ascethically pleasing treatment system. For warmer climates, a shaded structure is used.

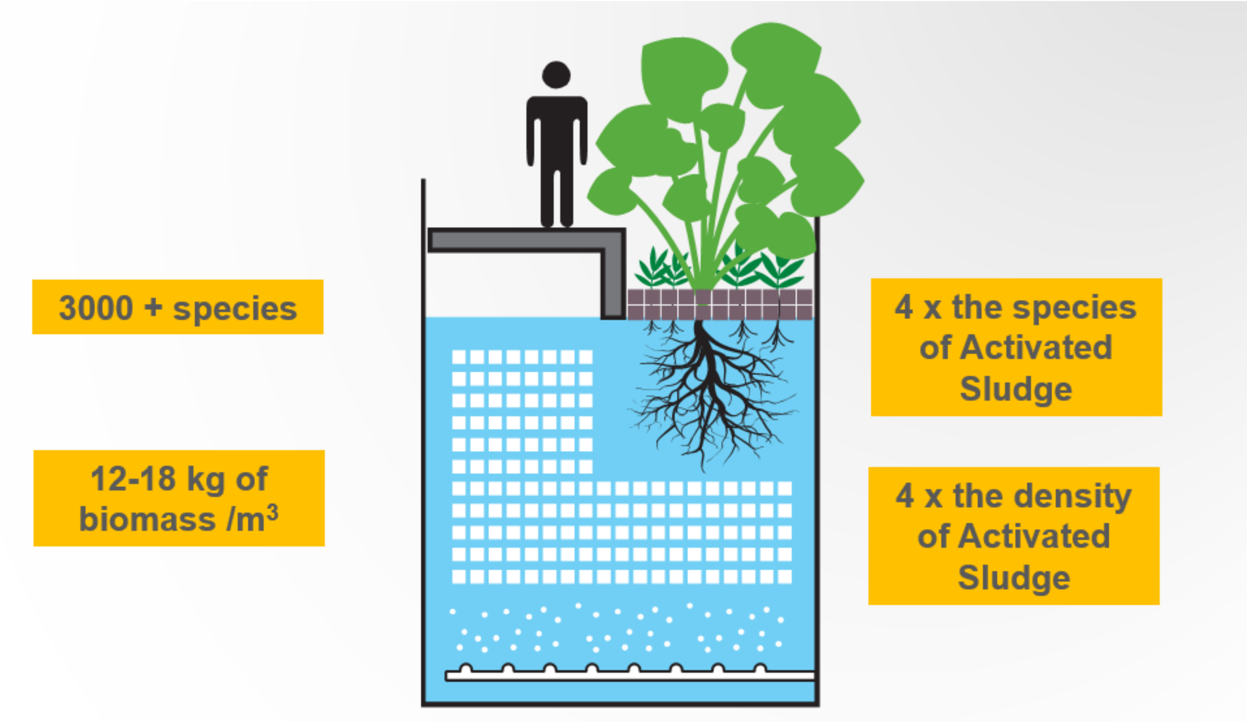


Figure 1: *Food Chain Reactor (FCR) – Cross section of the reactor process*

2.0 DISCUSSION

Pilot work for the FCR process was conducted in 2001, and was mostly based on the use of plants, to provide a high surface area for biomass growth. Full scale wastewater treatment plants were then constructed for 2000 and 5000EP systems, based on sequencing batch process.

Over the next eight years, the process was refined to enable the use of the technology in larger scale wastewater treatment plants, and to improve energy efficiency and with lower biomass yield.

2.1 The Development of Food Chain Reactor (FCR)

It was found that the use of natural plants on their own would not provide a commercial product with significant benefits over conventional aerobic processes and other bio-film based technology, despite the ascethically pleasing look of the treatment system.

Reactor depths were limited to less than 2 metres, leading to inefficient aeration and a large surface area requirement.

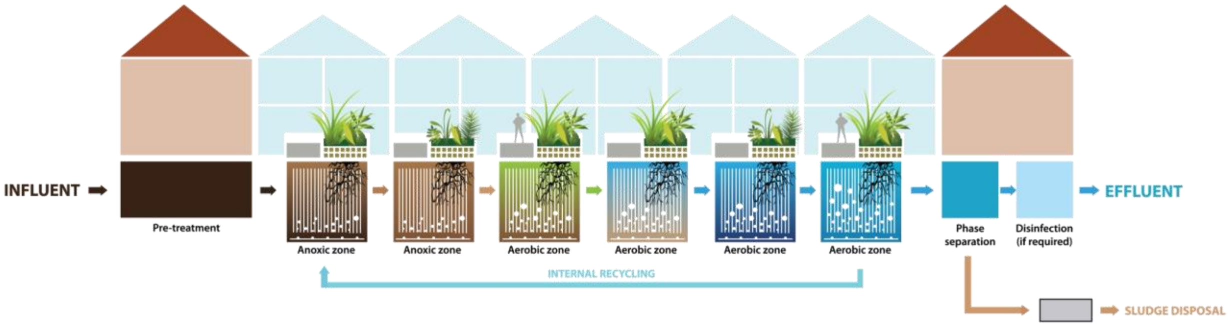
An engineered bio-film was then developed and designed to mimic the spatial characteristics of the natural plants. The modules were of a standard sizing with a depth allowing the bio-reactors to be up to 6M.

The combined use of the natural plants and engineered media meant that there was no limit on size for the FCR process.

2.2 Reactor Configuration

The sequencial batch process was then configured to a continuous multi-stage cascade process. Similar to MLE, an anoxic zone with internal recycle from the last stage was incorporated as part of the nitrogen removal loop.

Further piloting found that a six stage process provided significant advantages over the initial process configuration, and other bio-film based technologies.



<u>Figure 2:</u> ***The multi-stage Food Chain Reactor (FCR) process***

2.3 Observations from operating sites

The multi-stage cascade FCR was observed to provide a number of operational benefits. What was found in the pilot scale has been verified in full scale installations that have been in operation for several years.

Key observations include:

- Independent development of biomass and ecology within each stage
- A signficant increase in the diversity of biomass speciation due to the interaction of the natural plants and biomass
- Very high total biomass inventory, due to the biofilm growth
- Very high observied sludge retention time (SRT)
- Reduce Biomass Yield, due to a predatory effect and higher SRT
- A low MLSS in the water phase of 300 mg/L
- Increased alpha factor within the aeration system, due to the lower free MLSS
- Relatively free odour
- No need to return activated sludge (RAS) in process design

The lower free MLSS means that the phase separation step post FCR can be designed with a lower loading. Rather that using secondary clarifiers, phase separation can occur in a horizontal disc filter which has a tenth of the footprint as compared to a conventional clarifier.

In addition, the lower MLSS results in higher diffuser alpha factor, meaning that less air is required to deliver to process oxygen need. This results in a lower energy demand.

Diversity of biomass speciation results in adaptive ecologies forming in each FCR stage. As opposed to 300 to 400 species commonly present in activated sludge plants, the FCR exhibits up to 3000. This diversity creates a very stable process, which is tolerant to shock loads and in the last stage, the presence of eukaryotes results in the consumption of decayed bacteria.

2.3 Plant Operating Data

Full scale operating plants using the FCR process have been in operation for over five years. There are a total of 50 operating sites in Europe and Asia.

Table 1: ***Organica FCR – Some full scale installations***

Plant	Capacity	Location	Delivery
Le Lude STP	0.82 MLD	France	Greenfield
South Pest STP	80 MLD	Hungary	Retrofit
He Yuan STP	30 MLD	China	Retrofit

The technology has been applied as a retrofit to existing wastewater plants. The South Pest STP in Hungary is an example of a such a retrofit, whereby the existing MLE process was converted to a FCR system. He Yuan STP in China is a retrofit of an existing caroussel type process.

Table 2: ***Telk STP Hungary – Annual Average Performance Data***

Parameter	Influent (mg/L)	Actual Eff (mg/L)	Limit (mg/L)
COD	419.7	26.3	50.0
NH4-N	35.6	3.3	5.0
TN	55.1	8.6	15.0
TP	6.5	0.2	0.5
TSS	223.3	9.5	10.0

Operating data from several facilities has demonstrated the robustness of the FCR systems, as well as consistent effluent quality, as shown in Table 2. The discharge quality that can be achieved can be designed to match any conventional activated or MBR process.

The total observed biomass within the FCR system is typically 16,000 mg/L, which is three to four times convetional systems. Although MBR systems exhibit similar high MLSS, the energy demand associated with FCR is significantly less due to simplified secondary clarification phase.

2.4 Ascethetics

The FCR can be housed within a greenhouse structure, or provided with a shading structure. The selection is generally based on minimum temperatures in the winter period. The end result is a wastewater treatment plant that resembles a garden or greenhouse facility, with low odour emissions and a very ascethetically pleasing look.

In some European installations, buffer zones around the treatment plant has been reduced from 350m to 50m, freeing up additional land for development and providing a net positive attitude from local communities.

<u>Figure 3:</u> ***Le Lude STP – France. A view of the integrated process***

3.0 CONCLUSION

The use of bio-film technology provides a number of advantages with regard to footprint and biomass inventory. The combination of natural plants and IFAS results in a process that has been scaled up to full size treatment faciltities, that provides a number of capital and operational cost savings.

The natural plants do not actually treat the wastewater, but provide nutrients, organic acids and enzymes that create a highly diverse biology within the plant roots and IFAS modules. A much more dense bio-film is created, when compared to other IFAS systems or MBBR processes.

With an obversed total biomass concentration that is three times conventional systems, a reduced footprint of up to 65% can be achieved. Savings in energy demand and sludge disposal are two other key benefits of the process, particular over MBR based systems that exhibit similar space saving features.

Full scale installations as large as 80MLD have demonstrated the technology's application within the municipal and industrial wastewater field.

The acesthically pleasing look of the Organica FCR has changed local community attitude towards wastewater treatment, and has provided a place for communities to interact with process in a very positive way.

As rapid urban growth continues in many cities around the world, this technology has demonstrated its use as a decentralised facility that can be constructed in the middle of a dense urban landscape, to relieve load on existing sewer systems and enable water reclamation in these environments.

4.0 REFERENCES

Szilayi, Kovacs, Kenyeres and Csikor. *A bio-film based wastewater treatment technology for producing reclaimed water*

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