MODULAR PLASTIC MEDIA AND THE ENVIRONMENT

White Paper
WP

An analysis of the carbon footprint created during the production of modular plastic media and application in Trickling Filter wastewater treatment systems supplied by 2H Water Technologies

Abstract

As users (municipal and industrial) become more conscious of the environmental impact – and cost – of wastewater and industrial effluent treatment, many now require suppliers/contractors to provide details of the Carbon Footprint of the processes and products they propose to use.

This paper provides a detailed assessment of the carbon footprint of modular plastic media used in Trickling Filters, a proven technology used in municipal and industrial wastewater treatment, in sufficient detail to allow comparison with the environmental performance of alternative technologies such as Activated Sludge and Submerged Aeration systems.

The paper is divided into two sections:

1. Carbon Footprint Analysis

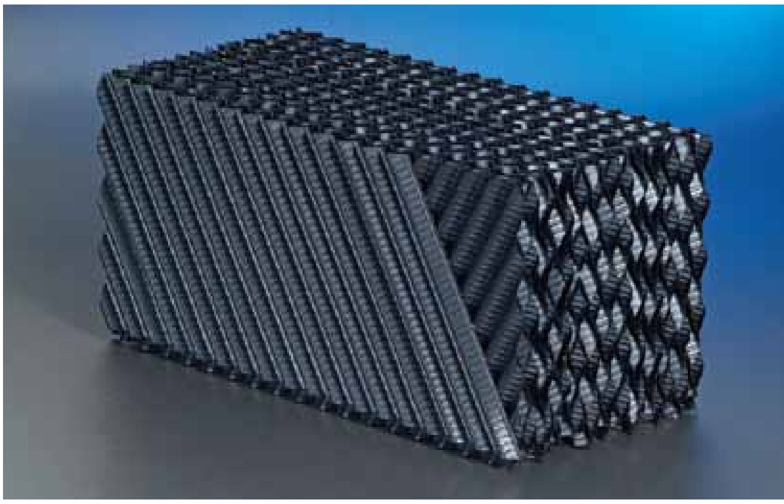
An evaluation of the carbon footprint created by modular plastic media – i.e. from manufacture/production through operational use in Trickling Filters. The figures provided cover the carbon cost accrued during:

- **a.** Production of PP (Polypropylene) and PVC used in the manufacturing of the plastic modules
- **b.** Installation of the media in Trickling Filter systems
- **c.** A notional 1-year operational period

2. Enviromental Impact

A brief discussion of the environmental impact of modular plastic media Trickling Filters when used in standard wastewater treatment applications – i.e. BOD (Carbonaceous) and Ammonia (Nitrification) treatment systems.

We also look at the potential use – and impact – of modular plastic media in Denitrification applications.



CARBON FOOTPRINT FACT

Trickling Filter media improves productivity and reduces energy use and carbon emissions

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Introduction

The analysis and statistics found in this document offer an updated and more detailed follow-up to a paper entitled "Comparing the Carbon Footprint of Anaerobic Membrane Bioreactor to other Sewage Treatment Processes" as presented by Jolly, Knight and Strutt at the European Wastewater Management Conference (ewwmconference.com).

We've expanded on the details highlighted in that paper on the proven ***low cost*** and ***low carbon footprint*** benefits of Trickling Filters built using modular plastic media.

Section 1: Carbon Footprint Analysis

There is an environmental drive away from glued PVC (Polyvinyl Chloride) towards welded PP (Polypropylene) plastic media for two main reasons: producing PP results in a lower carbon footprint and the material has characteristics that make for more effective recycling.

However, to ensure we're offering an accurate reflection of the current situation, this document includes some analysis of the carbon footprint of PVC as well as PP plastic media.

We've calculated the Lifetime Carbon Footprint using detailed information gathered by 2H Water Technologies on each of the stages involved in the production of modular plastic media – i.e. PP and PVC – including:

- Resin production
- Delivery of the resin
- Extrusion and formation of the resin into sheets from which the plastic modules are made

CARBON FOOTPRINT FACT

Manufacturing BIOdek foils generates 6.9kg CO_2 (PP) and 8.6kg CO_2 (PVC) per cubic metre of media

Production of CO_2 per kg of material produced

TABLE 1	PVC		PP	
	M_g CO_2	%age	M_g CO_2	%age
RESIN PRODUCTION	2,500,000	95.4	1,260,000	75.5
RESIN DELIVERY	21,000	0.8	8,100	0.5
EXTRUSION	100,000	3.8	400,000	24.0
TOTAL	2,621,000	100	1,668,100	100
TOTAL kg CO_2	2.621	100	1.668	100

We've also included data for elements of the manufacturing process specific to the plastic materials used, for example, adhesives used in the production of PVC and electrical power used to weld PP modules.

We have not included carbon footprint for the tanks in which the media is installed. As each water utility tends to take a different approach, there isn't a "standard" tank for Trickling Filter wastewater treatment on which we could base our calculations.

CARBON FOOTPRINT BREAKDOWN

PLASTIC PRODUCTION

As we've already discussed, the majority of modular plastic media is now produced in PP (Polypropylene).

Table 1 shows the total Carbon Footprint generated by manufacturing 1kg of either material (PVC or PP) to a point where it is ready to be formed into the ribbed foil sheets that are welded together rather than glued to form the modules used for the treatment process.

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FOIL FORMATION

PP (Polypropylene) - As PP is both extruded and formed in the same machine, the material doesn't have to be reheated before it's moulded into foils.

PVC - PVC foils are produced from sheet material supplied in rolls. The PVC sheet rolls are fed into a forming machine and heated prior to being forced into a mould using a vacuum and/or pressure feed. After being cooled to hold its form, the material is cut into foils of the required length.

Thickness Matters - A Trickling Filter will typically contain media varying in thickness depending on where the fill is situated in the media pack and the strength required to support the pack above it.

DELIVERY

Where the modules are manufactured in the main factory there is a delivery carbon footprint from there to the works where the Trickling Filter is sited. The average distance in the UK is 150 miles and the volume carried in a normal curtain sided articulated vehicle is $68m^3$.

CARBON FOOTPRINT FACT

The carbon cost per average delivery of BIOdek plastic media for onsite installation is 220kg per $68m^3$

INSTALLATION

We have calculated the combined carbon footprint for the following aspects of an average installation of media at $300m^3$ per day:

- Delivering modules to the installation site
- Operating a crane and forklift truck onsite to install the media
- Transportation for four installation personnel

25-YEAR OPERATION

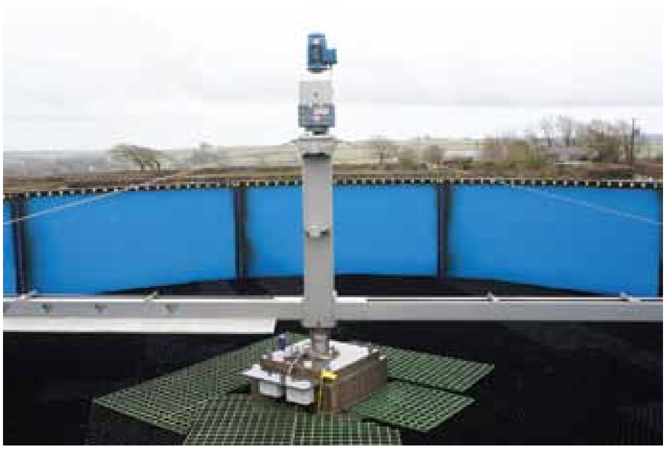
The only power consumption with its associated carbon footprint for the operation of a Trickling Filter system is for:

- Pumping power required to lift the feed to the distributor
- Distributor motor drive power

A Trickling Filter system only requires electricity to power the motor drive unit and pump for the feed. It may also be necessary to use a recycle pump when the feed flows drop below the minimum required for a healthy system. It is possible to use a single feed rather than a recycle pump if the system is designed to allow the treated effluent to be returned to the pump chamber by a flow meter/motorised valve system.

The pump is normally pumping up from a pump chamber directly to the distributor on a single filter or to a splitter tank for a multiple filter system.

The average media depth is close to 3600mm with a total pump lift height of 8m.



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Section 2: Environmental Impact

MODULAR PLASTIC MEDIA IN APPLICATION

We have focused this paper on areas of media production and application in which 2H Water Technologies has in-depth knowledge of the carbon footprint. This means that the carbon footprint for the civil construction of the filter system for bases, pump stations and enclosure tank are not included in any of these calculations.

The up-stream and down-stream carbon footprint is not covered in this paper as similar processes for screening, settlement and sludge disposal are required for all forms of biological treatment. Any comparison that is made between different processes will cover only the biological treatment.

How does the carbon Footprint of Modular Plastic Trickling Filters compare with other processes?

As over 90% of the carbon footprint for a Trickling Filter over its 25-year life results from the operation of the system, it is appropriate to compare this to the operational CO_2 production from the main alternative process of activated sludge.

CARBONACEOUS TREATMENT

The table below gives data for the production of CO_2 for a full Trickling Filter installation and one year's operation.

TABLE 2		PUMPED FLOW		GRAVITY FLOW	
MEDIA		PVC	PP	PVC	PP
CRUDE BOD/DAY	kg	420	420	420	420
SETTLED BOD/DAY	kg	315	315	315	315
AVERAGE FEED	m^3/day (l/sec)	1,900 (22)	1,900 (22)	1,900 (22)	1,900 (22)
TANK DIAMETER	m	13	13	21	21
MEDIA DEPTH	mm	3,600	3,600	1,800	1,800
MEDIA VOLUME	m^3	480	480	623	623
PROJECT MEDIA WEIGHT	kg	12,480	14,880	16,200	19,300
PLASTIC PRODUCTION/kg	**kgCO_2**	2.621	1.668	2.621	1.668
PROJECT PLASTIC PRODUCTION	**kgCO_2**	32,710	24,820	42,460	32,195
FOIL FORMING/m^3	**kg CO_2**	4,128	3,312	5,538	4,300
DELIVERY TO SITE[1]	**kg CO_2**	1,550	1,550	2,015	2,015
WELDING OF MEDIA	**kg CO_2**		600		780
PRODUCE AND APPLY GLUE	**kg CO_2**	1,890		2,453	
INSTALL AT SITE[2]	**kg CO_2**	620	620	800	800
TOTAL kg CO_2 OF INSTALLED MEDIA		40,898	30,902	53,266	40,090
OPERATE – 1 Year[3]	kg CO_2	23,386	23,386	3,737	3,737
Kg CO_2/100kg BOD TREATED/DAY		**20.34**	**20.34**	**3.25**	**3.25**

Notes: 1. Used average distance of 150 miles in 13m curtain-side truck | 2. Includes crane, forklift and transport for site team | 3. Covers feed pumps plus distributor motor drive

This is a fictional application example and is based on the following charateristics:

FLOW (m^3/d)	DWF 1520	AVE FLOW 1900	FFTT 4560
BOD CRUDE KG/D (mg/l)	420 (275)	420 (220)	420 (92)
SS CRUDE KG/D (mg/l)	460 (302)	460 (242)	460 (101)
BOD SETTLED KG/D (mg/l)	315 (207)	315 (166)	315 (69)
SS SETTLED KG/D (mg/l)	230 (151)	230 (121)	230 (50)
AMMONIA KG/D (mg/l)	57 (37.5)	57 (30)	57 (12.5)
FEED TEMPERATURE (DegC)	7	7	7
BOD CONSENT (mg/l)	25	25	25

CARBON FOOTPRINT FACT

A PP media installation has a lower carbon footprint than PVC at 1.668 vs 2.621 kg CO_2 per kg media used

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Section 2: Environmental Impact

COMPARISON FINE BUBBLE AERATION SYSTEM

A Fine Bubble Aeration system has been used as the basis of the comparison of CO_2 production for a Trickling Filter process versus an Activated Sludge process per 100kg of BOD treated.

TABLE 3	Kw	Kw hours/d	kg BOD TREATED/DAY	Kw Hour/kg BOD	Kw hour/100Kg BOD	$kgCo_2$/100Kg BOD TREATED/DAY
FINE BUBBLE SYSTEM						
BLOWER	22	528	315	1.68	167.62	59.67
FEED PUMP (7 mtr Head)	4.7	112.8	315	0.36	35.81	12.75
RAS PUMP	2.3	55.2	315	0.18	17.52	6.24
TOTAL	29	696	315	2.21	220.95	78.66
PUMPED FLOW TRICKLING FILTER						
FEED PUMP (8 mtr Head)	6.3	151.2	315	0.48	48.00	17.09
MOTOR DRIVE	1.2	28.8	315	0.09	9.14	3.25
TOTAL	7.5	180	315	0.57	57.14	20.34
GRAVITY FLOW TRICKLING FILTER						
FEED PUMP (8 mtr Head)	0	0	315	0.00	0.00	0.00
MOTOR DRIVE	1.2	28.8	315	0.09	9.14	3.25
TOTAL	1.2	28.8	315	0.09	9.14	3.25

Note: 1kw/hr = 0.356 kg CO2

CARBON FOOTPRINT FACT

BIOdek Trickling Filters use 50-75% less energy than activated sludge plants

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TRICKLING FILTERS FOR CARBONACEOUS OXIDATION (BOD)

As the majority of Trickling Filters are designed to remove carbonaceous BOD, it can be assumed that the majority of modular plastic media will be used for this purpose.

Modular plastic media can be used to upgrade existing plant - for example, as a replacement for shallow rock media – or in new Trickling Filter installations – for example, to create tower systems (with media 6000mm in depth) in order to reduce BOD to consent levels between 12 and 25mg/l.

A Trickling Filter tower system of that size would also offer the potential to reduce ammonia to 5mg/l all with 95%ile consent.

The volume of $150m^2/m^3$ media required to remove 1kg BOD in normal municipal wastewater depends on the depth of the media and the temperature of the feed liquor. Accurate modelling of the process is achieved using the modified Velz equation.

CARBON FOOTPRINT FACT

Trickling Filters built from recyclable BIOdek plastic media can be upgraded to improve performance and extend operational lifetime

NITRIFYING FILTERS

Nitrifying filters fall into two categories: **single pass** and **duplex filter** systems.

Single Pass: The traditional single pass Nitrifying Filter is normally a tower filter between 3000mm and 6000mm media depth and producing ammonia consents down to 3mg/l 95%ile from a feed of normal strength sewage with a single pass system.

A modular plastic media Trickling Filter can produce a 95%ile ammonia consent of 2mg/l.

Duplex Filter: To achieve this, a duplex filter system must be run in Alternating Directional Flow (ADF). Running a duplex system in ADF involves the flow passing through Filter 1 and on to Filter 2 for 5 to 7 days and then the flow altered to go to Filter 2 first and then through Filter 1. A system of this type would double the carbon footprint of a non ADF system as it is pumped twice but not the manufacturing and installation footprint as the media volume remains the same and is just split between two tanks.

The level of ammonia treatment in a modular plastic media filter is directly related to the surface area installed for each kg AmmN to be treated. The area per kilogram treated is modified by the AmmN concentration and the temperature of the feed liquor and is modelled by the Guyer and Boller equation.

CONCLUSION

As we have already discussed, according to the paper by Jolly, Knight and Strutt which provided the catalyst for this analysis, carbon footprint tracking for specific processes was in its infancy. Over a decade later it's now possible to provide a full breakdown of the carbon footprint across the manufacture, installation and operation of modular plastic media Trickling Filters.

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