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Advances in the development of biological biofilm support materials for sewage treatment plants: a review

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Highlights:

- Select the ideal biofilm support materials are important since it can be inffluence the sewage treatment.
- The material used in comercial biological support is mainly formed by inorganic materials.
- Alternatives materials research, mainly ecofriendly materials are important to the advance of this area.

Keywords: biological materials, sewage treatment, biofilm formation.

INTRODUCTION

Surface water is a source of water for human consumption, with the continuous growth in water use, a large amount of effluent is discarded every day into the environment (Mehrotra et al., 2021). Many synthetic and natural chemicals, including organic matter, microorganisms, nutrients, metals, and inorganic matter cause environmental damage due to their discharges (Naidu et al., 2021). To ensure quality water for downstream cities, effective sewage treatment is required.

Biological treatment processes are more cost-effective than physical and chemical treatments and also have a great potential to degrade a large part of biodegradable organic compounds (Mehrotra et al., 2021; Naidu et al., 2021). One of the types of biological processes are attached growth systems, in which biomass grows on a supporting medium. Aiming at this, several new types of biofilm support materials used in biological reactors have been researched, natural materials such as loofah, zeolite and volcanic stones as well as synthetic polymers have been tested to improve the development of the biofilm by improving the treatment.

This review focused on new types of product that are being evaluated for use in a bed biological reactor for sewage treatment, with the aim of showing what is most recent so that it can also be tested by other researches.

METHODOLOGY

For this review, we focused on the most recent research on filler materials used in sewage treatment. To do this, we used the advanced search on the CAPES journal portal. The search limited articles from the last ten years, in English, containing the words “Bio-carriers” or “Biofilm carriers”, or “biocarriers”.

The following filters were added to the search: "Watewater treatment", "Bioreactors", "reactors", "biofilm", "Wastewater", "biofilms", excluding "water treatment.

RESULTS AND CONCLUSIONS

After advanced search on the CAPES journal portal we found 33 articles, following the exclude criteria we could verify that 27 articles used different types of material for biofilm supporting for sewage treatment.

There are several types of commercial supports, with different materials such as high-density polyethylene, polypropylene and also polyethylene, of different sizes and shapes (Table 1) (Barwal & Chaudhary, 2014). These support materials were classified into inorganic material, natural organic polymers and synthetic organic polymers; each material has its own characteristics and resulted in different effects (Mehrotra et al., 2021).

Modelo	Empresa	Material	Altura	Diametro	àrea especifica (m^2/m^3)	Referências
K1	AnoxKaldnes™ (Sweden)	HDPE	7,1	9,5	500	(Das & Naga, 2011)
K2	AnoxKaldnes™ (Sweden)	HDPE	15,25	15,2	350	(Das & Naga, 2011)
K3	AnoxKaldnes™ (Sweden)	HDPE	12,6	25,1	500	(Das & Naga, 2011)
Natrix C2	AnoxKaldnes™ (Sweden)	HDPE	30,4	36,4	220	(Das & Naga, 2011)
Natrix M2	AnoxKaldnes™ (Sweden)	HDPE	50,2	64	200	(Das & Naga, 2011)
Biofilm-Chip M	AnoxKaldnes™ (Sweden)	HDPE	2,01	48,2	1200	(Das & Naga, 2011; Bassin et al., 2016)
Biofilm-Chip P	AnoxKaldnes™ (Sweden)	HDPE	3,1	45,4	900	(Das and Naga, 2011)
FLOCOR-RMP	FLOCOR-Henderson Plastics Ltd. (UK)	PE	10,2	15,3	260	(Das and Naga, 2011; Bassin et al., 2016)
Newpond	Newpond®	PEAD	20	50	500	(Wang et al., 2020; Kusuma et al., 2019)
Polyurethan biofilm carrier	Ecolucht B.V.	Poliuretano	9	13	1000	(Ahmad et al., 2017)
BWTX ™	Biowater Technology	PEAD	15	10	640	(Ahmad et al., 2017; Wang et al.,2020)
BWT15 ™	Biowater Technology	PEAD	15	5	828	(Wang et al., 2020)
Kingsponge	Shanghai Yinke Co. Ltd	Poliuretano	20	5	20000	(Chen et al., 2015)
Bioportz	Entex Technologies	PEAD	14	18	590	(Bakar et al., 2018; di Biase et al.,2021)
FLOCOR RS	FLOCOR-Henderson Plastics Ltd. (UK)	PE	36,3	37,6	>=230	FLOCOR
FLOCOR RM	FLOCOR-Henderson Plastics Ltd. (UK)	PE	27	22	>=400	FLOCOR
BioSphere	Seimens (USA)	PE	9	12	800	BioSphere™
BioSphere N	Seimens (USA)	PE	9	12	800	BioSphere™
Spira 12	Seimens (USA)	PE	12	12	650	BioSphere™
Spira 14	Seimens (USA)	PE	14	14	600	BioSphere™
ActiveCell 450	Hydroxyl Systems Inc. (USA)	HDPE	15	22	402	Aquapoint
FXP-25/10	Fxsino (China)	PE	15	20	600	Fxsino-MBBR carrier
Bio-media	Fxsino (China)	PE	10	15	>550	Fxsino-MBBR carrier
BioMini Pack	Fxsino (China)	PE	10	15	500	Fxsino-MBBR carrier

Table 1: Articles that used commercial biofilms supports materials on the market.

There is research that studies different types of materials, their effect on the effectiveness of the treatment and also the colonies of bacteria present in them (Table 2).

Material	Origem do esgoto	Tipo de reator	Escala	Tempo de detenção (h)	Eficácia da remoção DQO (%)	NH3 (%)	Outros poluentes	Referências
HDPE/PLA/Zn NPs(10-30%)	Esgoto textil pretratado	RBLM	Bancada		57-78	59-79		(Wang et al., 2018)
polyvinyl alcohol (PVA)	Esgoto sintético	RBLF	Bancada	3,8 a 4		92,5-97,2		(Wang et al., 2020)
Pad SentecTM	Esgoto industrual com hidrocarbonetos	RBLF	Bancada	0,06			Hidrocarbonetos92, 6%	(Calvo et al., 2020)
CorkSorb TM 1025	Esgoto industrual com hidrocarbonetos	RBLF	Bancada	0,06			Hidrocarbonetos 97,5%	(Calvo et al., 2020)
Barrier Sentec TM	Esgoto industrual com hidrocarbonetos	RBLF	Bancada	0,06			Hidrocarbonetos 94,5%	(Calvo et al., 2020)
Magnetic porous carriers	Esgoto sintetico	RBLF	Bancada	4	91	94		(Tong et al., 2021)
Porus polymer carriers	Esgoto sintético	RBLF	Bancada	4	98	90		(Tong et al., 2021)
Kaldnes K1 de PEAD	Esgoto de industria lactea	SBBR	Bancada	192	81,8	85,1	PO4 94%	(Ozturk et al., 2018)
Kaldines K3 de PVC	Esgoto somtetico	MBSBR	Piloto	1,5 a 3,5	62-98,8	73,1-98,8	TP 72,3 - 40	(Seyedsalehi et al., 2017)
Bucha modificada	Esgoto domestico	RBLM	Piloto	3 a 7	90-82,8	90,4		(Dang et al., 2020)
Portatores microbianos anaerobicos - Biogel poroso	Esgoto domestico	RBLM	Bancada		80	95		(Li et al., 2023)
PU foan	Esgoto sintético	RBLF	Bancada	12 e 24	84,5-93,1	97,7	TN (39,9% - 81,4%)	(Fan e Zhou 2023)
Nylon	Esgoto sintético	RBLSM	Bancada	2,5 - 8	91.6 %	83.68 %		(Dong et al., 2015)
Poliol com isocianato	Esgoto sintético	RBLSM		24	>90 %	70%		(Tang et al., 2017)
PLC	Esgoto sintético	RBLM	Bancada		87,75	94,77		(Xie et al., 2020)
N/C	Esgoto sintético	RBLM		4	88,5	93,43		(wan et al., 2020)
Acrilato	Esgoto sintético	RBLM	Bancada			92,7-99,3		(Proano-Pena et al.,2020)

Table 2: List of articles that used alternative materials (no commercial) as biofilm support to sewage treatment.

Zhou et al. (2021), compared biofilm development in an anaerobic treatment between high-density polyethylene (HDPE), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), polyvinyl chloride (PVC), polypropylene (PP), polyvinylidene fluoride (PVDF) and polymethyl methacrylate. This experiment showed that hydrophilic materials after 81 days showed greater amounts of mature biofilms, and ABS and HDPE had better performance for removing chemical oxygen demand from the effluent.

Different materials, with variable surface areas and shapes, interfere with biofilm development. To this end, it is necessary to carry out researches to a better material selection to achieve the desired treatment effectiveness for the type of sewage to be treated.

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