Prospecção tecnológica

Tratamento de água: Remoção de MIB e Geosmina

sabesp

Superintendência de Pesquisa,
Desenvolvimento Tecnológico e Inovação - TX

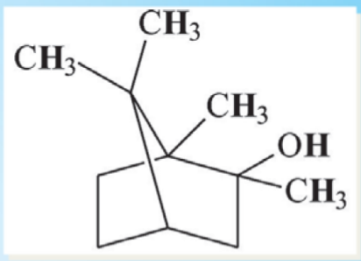
Julho/2014

Objetivo / Importância

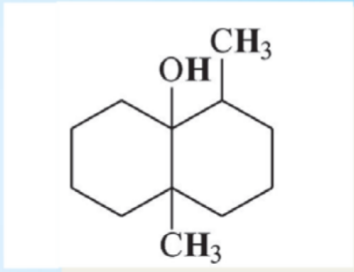
Mapeamento dos desenvolvimentos científicos e tecnológicos através da busca de artigos científicos e patentes

Aspectos gerais

cianobactérias → (Carga orgânica e nutrientes; Altas temperaturas e insolação) → Proliferação de cianobactérias → (metabolismo → **MIB**; biodegradação → **geosmina**)



2-metil isoborneol



trans-1,10-dimetil-trans-9-decalol

Fonte: Freitas et al. 2008

Subprodutos de cianobactérias:

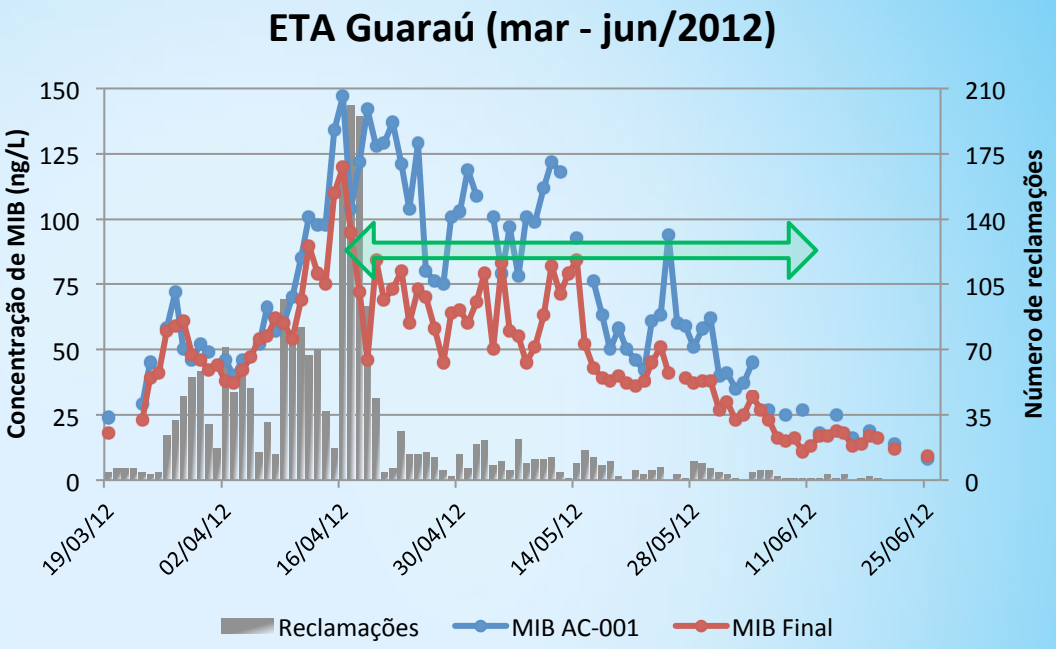
- compostos causadores de gosto e odor, **MIB e geosmina;**
- outros metabólitos; e
- diversas cianotoxinas.

Limite de percepção → 4~20 ng/L → gosto e odor **mofo / terra**

Aspectos gerais

Sistemas Produtores RMSP:

- Alto Tietê
- Guarapiranga
- Cantareira – MIB (2007 e 2012)



Experimentos:

ETA Biritiba Mirim: Aplicação de H_2O_2 + Fe^{2+} (Fenton) para remoção de MIB/GSM (MLEC, 2007)

- Resultados satisfatórios
- Problema com pH → corrosão

ETA ABV: Aplicação de H_2O_2 + UV MIB (acompanhado pela TXE, 2013)

- Resultados satisfatórios

Metodologia

Delimitações:

Período de abrangência:
2007 a 2012 (6 anos)

Bases de pesquisa:

- Artigos científicos:
  Web of Science
- Patentes:
  USPTO (Elabmapper)
  Derwent

Matriz de palavras-chave e expressão de busca

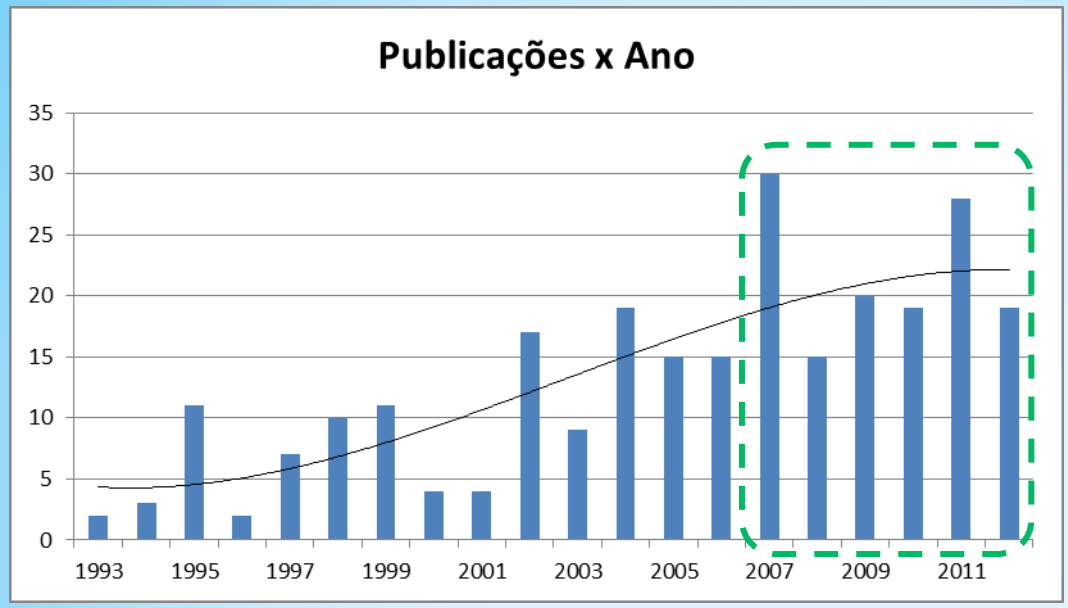
Termo 1 (tópico)	Termo 2 (tópico)	Termo 3 (tópico)	Termo 4 - NOT (tópico)		Termo 5 - NOT (área de conhecimento)
water	remov*	*methylisoborneol	aquaculture	sea	agriculture
	withdraw*	*methyl isoborneol	waste$water	bamboo	marine freshwater biology
	clearance	MIB	*fish	wireless	
	eliminat*	geosmin	*anatoxin	food	
	degrad	GSM	hepatotoxin	mushroom	
	reduc*	cyanobacteri* NEAR/ 1 metabolite*	marine	network	
	treat*		blood	weather prediction	
	destruction		rats	GSM satellite	
			mouse	GSM transmission	

ou

e

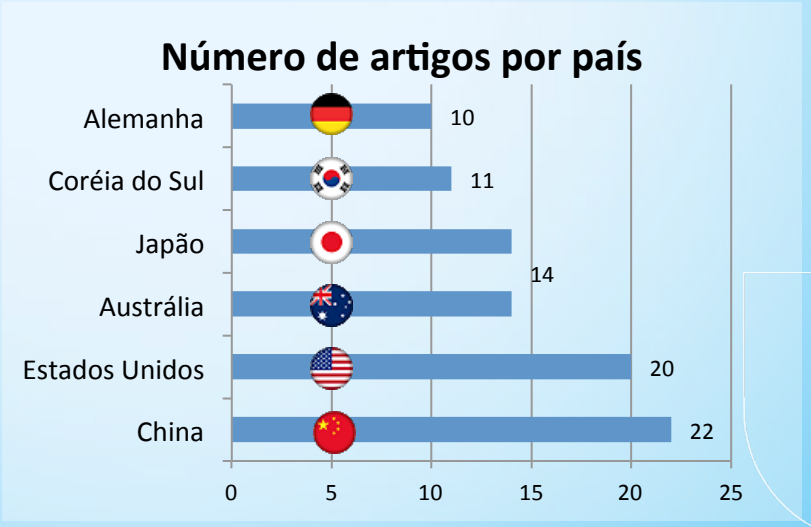
TS=(water) AND TS=(remov* OR withdraw* OR clearance OR eliminat* OR *degrad* OR reduc* OR treat* OR destruction) AND TS=(*methylisoborneol OR *methyl isoborneol OR MIB OR geosmin OR GSM OR cyanobacteri* NEAR/1 metabolite*) NOT TS=(aquaculture OR waste$water OR *fish OR *anatoxin OR hepatotoxin OR marine OR blood OR rats OR mouse OR sea OR bamboo OR wireless OR food OR mushroom OR network OR weather prediction OR GSM satellite OR GSM transmission) NOT SU=(agriculture OR marine freshwater biology)

Busca de artigos e patentes



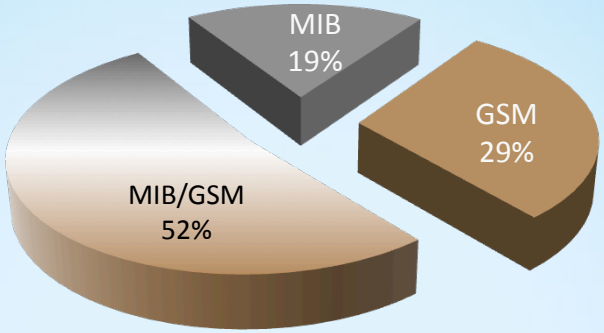
6 anos
131 artigos

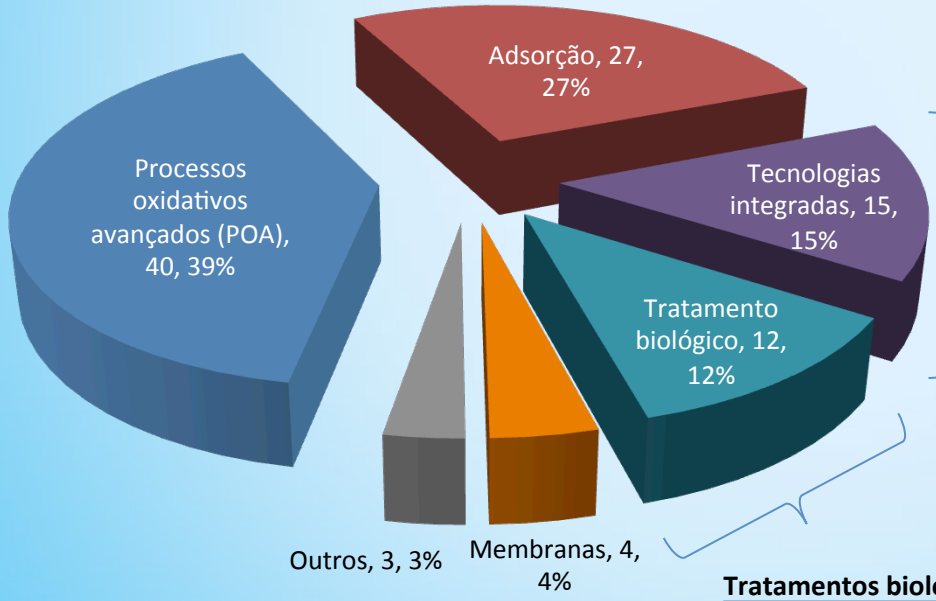
98 artigos pertinentes



Tecnologias de tratamento

Distribuição dos artigos por composto



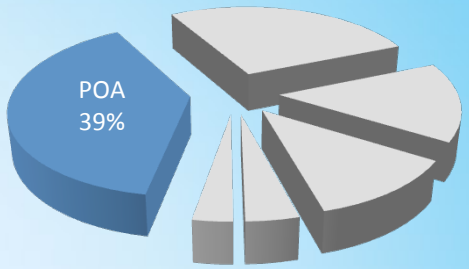


Tecnologias integradas	**15**
DAF and PAC	2
GAC and O_3	2
Adsorption and biodegradation	1
BAC and O_3	1
GAC and O_3/BAC	1
Membrane, O_3 and BAC	1
MIEX, coagulation and GAC	1
MIEX, MF and GAC	1
PAC and air stripping	1
PAC, coagulation and ceramic microfiltration	1
Potassium permanganate and PAC	1
S-PAC and microfiltration	1
UF-BPAC	1

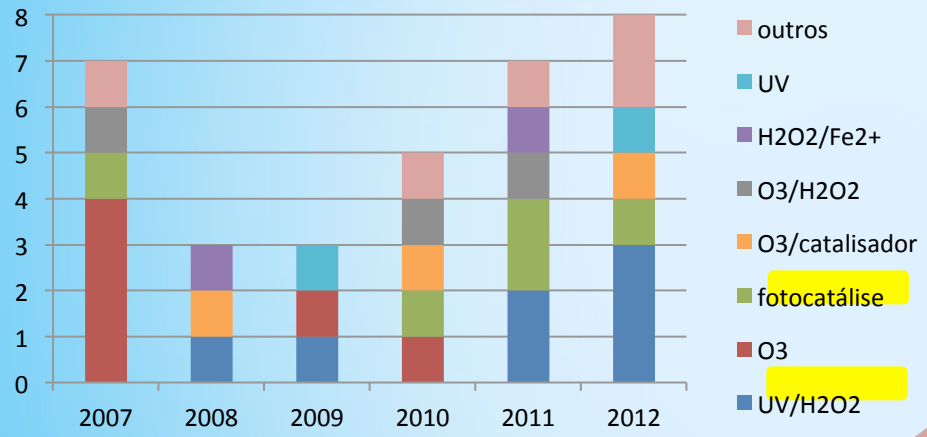
Tratamentos biológicos	**12**
Biofiltração	6
Biodegradação	5
Biotransformação	1

Processos oxidativos avançados (POA)

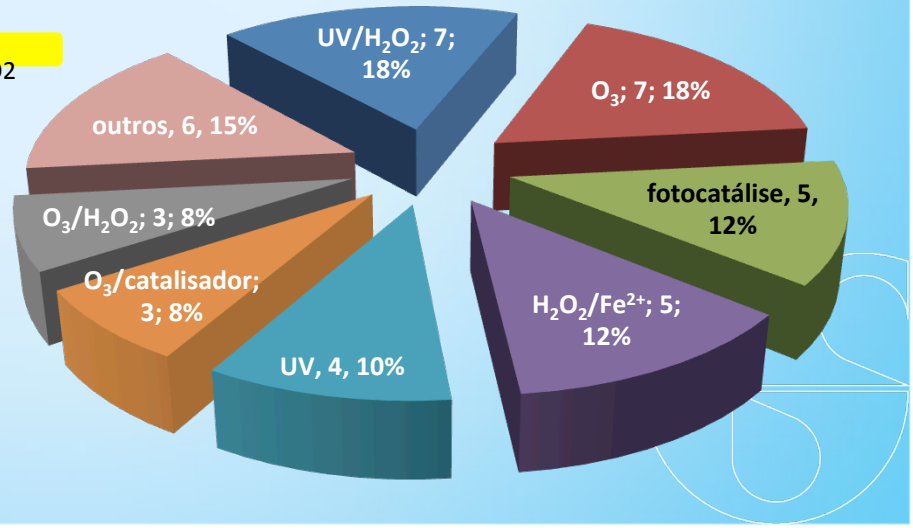
Uso da capacidade degradativa dos oxidantes químicos fortes, radicais hidroxila (OH^-), gerados in situ



Distribuição temporal dos artigos por subtecnologia predominante



Distribuição das subtecnologias de POA



Processos oxidativos avançados

H_2O_2 + UV

fotólise do H_2O_2 pelo UV → radicais OH^-

- Reação com radicais hidroxila
- Parcialmente pela fotólise direta pelo UV

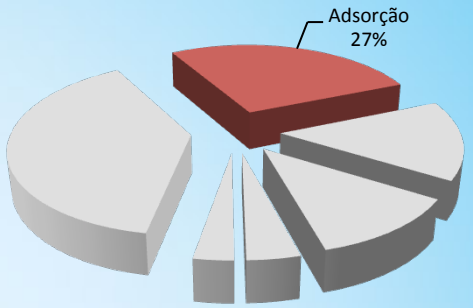
Fotocatálise

O catalisador sólido funciona como um semicondutor que ao ser irradiado, promove a dissociação das moléculas, gerando radicais altamente reativos.

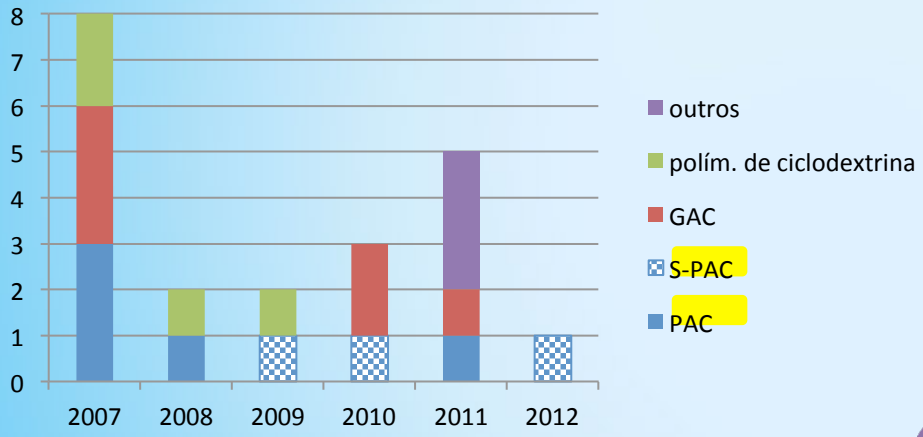
- a **eficiência** comprometida pela matéria orgânica natural ou da turbidez;
- dificuldade para **dosagem dos produtos químicos** de acordo com a severidade;
- **altas concentrações** tempos de contato longos ou estágios adicionais;
- **custos** modificações;
- dificuldade de **adaptação do UV** para **grandes vazões**;
- custos **produtos químicos**;
- consumo de **energia elétrica;**
- **eficiência**;
- **não aumenta** a geração de lodo.

Adsorção

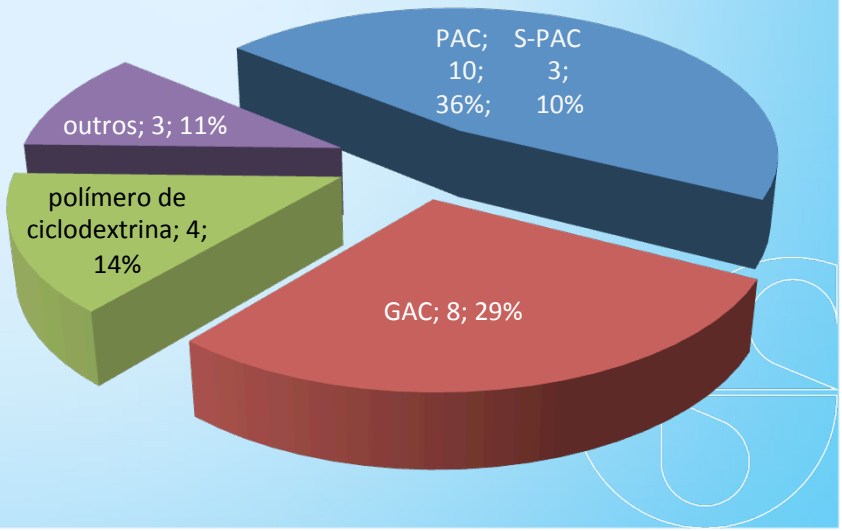
Adesão de moléculas de um fluido (adsorvido)
a uma superfície sólida (adsorvente)



Distribuição temporal dos artigos por subtecnologia predominante



Distribuição das subtecnologias de Adsorção



Adsorção

PAC, S-PAC

Materiais de alta porosidade com grande área superficial interna (teor de carbono e método de ativação)

- Eficiência de remoção pode ser **comprometida**;
- Impossibilidade de **regeneração** → Geração de **lodo**;
- Problemas **logísticos** para ETAs de **grande porte**;
- **Custos** associados;
- **Flexibilidade** devido à fácil aplicação. Possibilidade de estudar o **melhor ponto** de aplicação (mistura, tempo de contato, competitividade);
- **Dosagem** de acordo com a **severidade**;
- **Não demanda** grandes modificações.

Artigos mais citados

Título	Tecnologia	Subtecnologia	Autores	País	Periódico	Ano	Citações
Biodegradation rates of 2-methylisoborneol (MIB) and geosmin through sand filters and in bioreactors	Tratamento biológico	biofiltração	Ho, Lionel; Hoefel, Daniel; Bock, Franziska; Saint, Christopher P.; Newcombe, Gayle	Australia, Alemanha	Chemosphere	2007	35
Oxidation kinetics of selected taste and odor compounds during ozonation of drinking water	Processos oxidativos avançados	ozonização	Peter, Andreas; Von Gunten, Urs	Suiça	Environmental Science & Technology	2007	31
Removal of organic contaminants from water using nanosponge cyclodextrin polyurethanes	Adsorção	polímeros de ciclodextrina	Mhlanga, Sabelo D.; Marnba, Bhekie B.; Krause, Rui In; Malefetse, Tshepo J.	África do Sul	Journal of Chemical Technology and Biotechnology	2007	24
Photoinitiated oxidation of geosmin and 2-methylisoborneol by irradiation with 254 nm and 185 nm UV light	Processos oxidativos avançados	UV; UV/VUV	Kutschera, Kristin; Boernick, Hilmar; Worch, Eckhard	Alemanha	Water Research	2009	19
Enhancing the biofiltration of geosmin by seeding sand filter columns with a consortium of geosmin-degrading bacteria	Tratamento biológico	biofiltração	McDowall, Bridget; Hoefel, Daniel; Newcombe, Gayle; Saint, Christopher P.; Ho, Lionel	Australia	Water Research	2009	15

Journal of Chemical Technology and Biotechnology *J Chem Technol Biotechnol* 82:382–388 (2007)

Removal of organic contaminants from water using nanosponge cyclodextrin polyurethanes

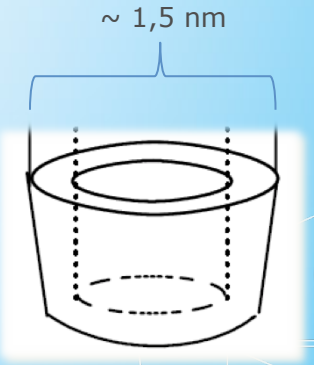
Sabelo D Mhlanga, Bhekie B Mamba, Rui W Krause* and Tshepo J Malefetse

University of Johannesburg, Department of Chemical Technology, P.O.Box 17011, Doornfontein, 2028, South Africa

Abstract: Insoluble nanoporous cyclodextrin (CD) polymers were synthesized using bifunctional isocyanate linkers. The ability of these polymers to remove selected organic pollutants from water at varying concentrations was studied. The investigated pollutants were selected high-priority chlorinated disinfection by-products (DBPs) and a common odour-causing compound in water, 2-methylisoborneol (2-MIB). The unpleasant musty odour imparted by 2-MIB and geosmin in water can be detected by the human nose even at ng L^{-1} (parts per trillion) levels. Pre-concentration and extraction of water samples containing low levels of pollutants was performed using solid phase extraction (SPE) and subsequently quantified by gas chromatography-mass spectrometry (GC/MS). Here we show that the CD polymers demonstrate excellent absorption efficiency (>99%) with respect to the organic pollutants, considerably better than granular activated carbon (GAC). The recyclability efficiency of these CD polymers is also reported.

Polímeros de ciclodextrina

- forma toroidal de cone truncado,
- cavidade hidrofóbica e superfície hidrofílica → encapsulamento
- **menor interferência** teor de matéria orgânica natural
- possibilidade de **regeneração**



Considerações

- A escolha da tecnologia deve considerar:

Composto alvo x Frequência de ocorrência x Matéria orgânica x Flexibilidade das instalações x Questões logísticas x Adaptação escala x Custo das adequações físicas x Custos operacionais

- Sobretudo, por se tratar de um problema ocasional (sazonal), a solução deve ser **flexível**, de resposta **rápida** e que não demande grandes **modificações**.

- Paralelamente devem ser avaliadas as **medidas de controle** que visem **evitar** as condições que favoreçam o **aumento** das cianobactérias nos **reservatórios** de abastecimento superficiais, como: **ocupação irregular** do entorno, **lançamentos** de cargas de poluentes e **degradação** de matas ciliares.

Obrigada

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Departamento de Prospecção Tecnológica
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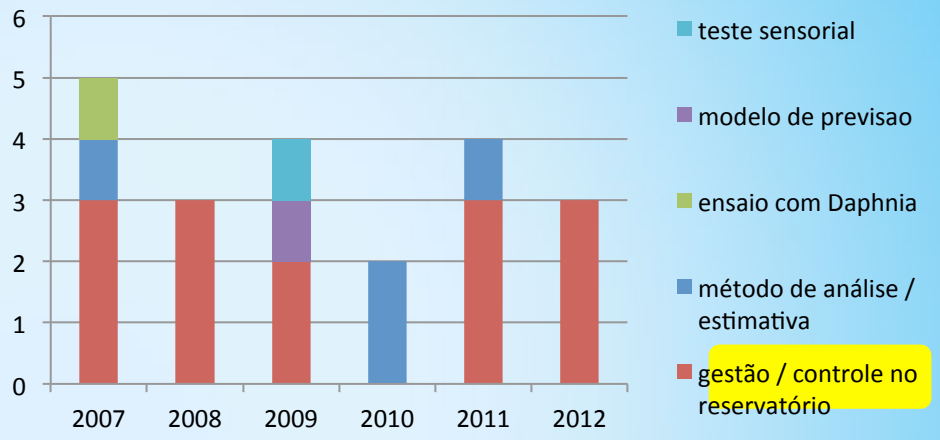
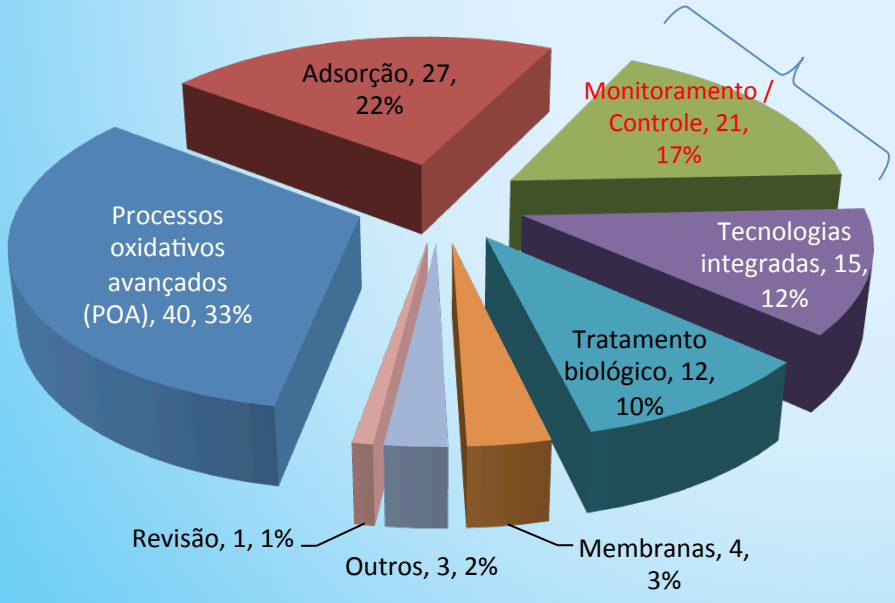
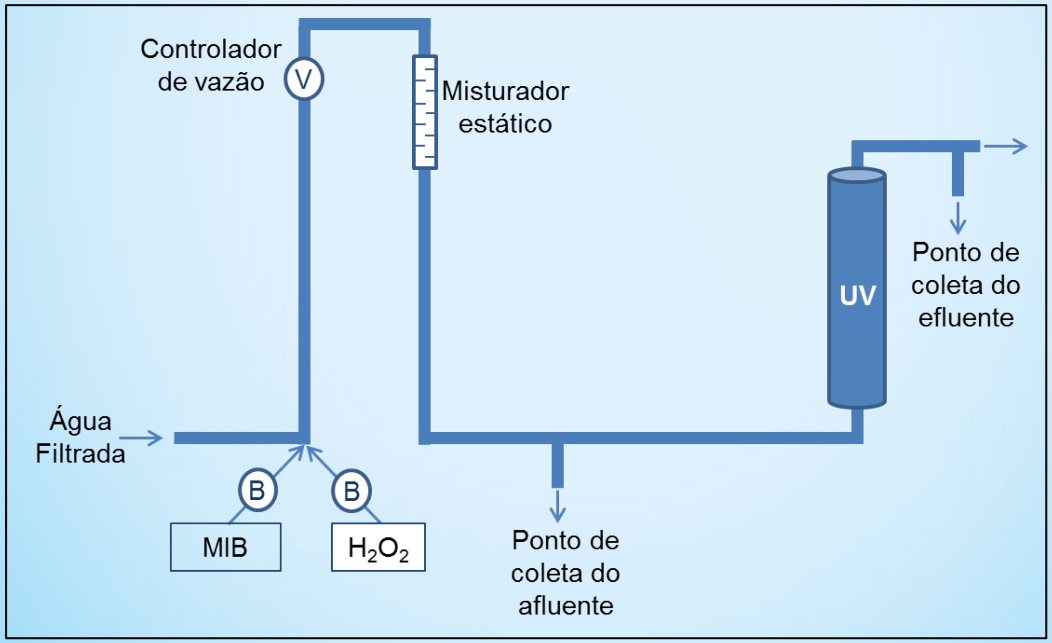
Resultados

Distribuição temporal das subtecnologias de Monitoramento e Controle



Porcentagem e número de artigos classificados por tecnologia




Controlador
de vazão
V
Misturador
estático
UV
Ponto de
coleta do
efluente
Água
Filtrada
B
B
MIB
H_2O_2
Ponto de
coleta do
afluente

Available online at www.sciencedirect.com
ScienceDirect
Chemosphere 66 (2007) 2210–2218
CHEMOSPHERE
www.elsevier.com/locate/chemosphere

Biodegradation rates of 2-methylisoborneol (MIB) and geosmin through sand filters and in bioreactors

Lionel Ho [a,*], Daniel Hoefel [a], Franziska Bock [b], Christopher P. Saint [a], Gayle Newcombe [a]

[a] *Cooperative Research Centre for Water Quality and Treatment, Australian Water Quality Centre, SA Water Corporation, PMB 3, Salisbury SA 5108, Australia*
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Available online 26 September 2006

Abstract

Taste and odour (T&O) causing compounds, in particular, 2-methylisoborneol (MIB) and geosmin, are a problem for water authorities as they are recalcitrant to conventional water treatment. In this study, biological sand filtration was shown to be an effective process for the complete removal of MIB and geosmin, with removal shown to be predominantly through biodegradation. In addition, MIB and geosmin were also effectively degraded in batch bioreactor experiments using biofilm sourced from one of the sand filters as the microbial inoculum. The biodegradation of MIB and geosmin was determined to be a pseudo-first-order reaction with rate constants ranging between 0.10 and 0.58 d^{-1} in the bioreactor experiments. Rate constants were shown to be dependent upon the initial concentration of the microbial inoculum but not the initial concentration of MIB and geosmin when target concentrations of 200 and 50 ng l^{-1} were used. Furthermore, rate constants were shown to increase upon re-exposure of the biofilm to both T&O compounds. Enrichment cultures with subsequent community profile analysis using 16S rRNA-directed PCR-DGGE identified four bacteria most likely involved in the biodegradation of geosmin within the sand filters and bioreactors. These included a *Pseudomonas* sp., *Alphaproteobacterium*, *Sphingomonas* sp. and an *Acidobacteriaceae* member.

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Enhancing the biofiltration of geosmin by seeding sand filter columns with a consortium of geosmin-degrading bacteria

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[a]*CRC for Water Quality and Treatment, Australian Water Quality Centre, SA Water Corporation, PMB 3, Salisbury, SA 5108, Australia*
[b]*School of Chemical Engineering, University of Adelaide, SA 5005, Australia*
[c]*School of Earth and Environmental Sciences, University of Adelaide, SA 5005, Australia*

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Biological filtration (biofiltration)
Consortium
Geosmin
Inoculation
Seeding
Water treatment

ABSTRACT

Geosmin is a secondary metabolite that can be produced by many species of cyanobacteria and *Actinomycetes*. It imparts a musty/earthy taste and odour to drinking water which can result in consumer complaints and a general perception that there is a problem with the water quality. As geosmin is recalcitrant to conventional water treatment, processes are sought to ensure effective removal of this compound from potable water. Biological filtration (biofiltration) is an attractive option for geosmin removal as this compound has been shown to be biodegradable. However, effective biofiltration of geosmin can be site specific as it is highly dependent upon the types of organism present and there is often an extended acclimation period before efficient removals are achieved. We report here, a novel approach to enhance the biofiltration of geosmin by seeding sand filter columns with a bacterial consortium previously shown to be capable of effectively degrading geosmin. Geosmin removals of up to 75% were evident through sand columns which had been inoculated with the geosmin-degrading bacteria, when compared with non-inoculated sand columns where geosmin removals were as low as 25%. These low geosmin removals through the non-inoculated sand columns are consistent with previous studies and were attributed to physical/abiotic losses. The presence of an existing biofilm was shown to influence geosmin removal, as the biofilm allowed for greater attachment of the geosmin-degrading consortium (as determined by an ATP assay), and enhanced removals of geosmin. Minimal difference in geosmin removal was observed when the geosmin-degrading bacteria were inoculated into the sand columns containing either an active or inactive biofilm.