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Effect of aeration rate on the performance of a novel non woven flat plate bioreactor

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Background

Wastewater treatment systems

- **Biomass suspended**
- **Fixed Biofilm**

Advantages (Gómez-De Jesús et. al., 2009; Bajaj, 2008)

- Smaller reactor volume
- Reduced operating and energy costs
- Resistance to short-term toxic loads
- Present a robust performance under variable influent concentrations of a mixture of inhibitory compounds (Buitrón and Moreno-Andrade , 2011)

Disadvantages (WEF, 2011; Gómez-De Jesús, et. al., 2009)

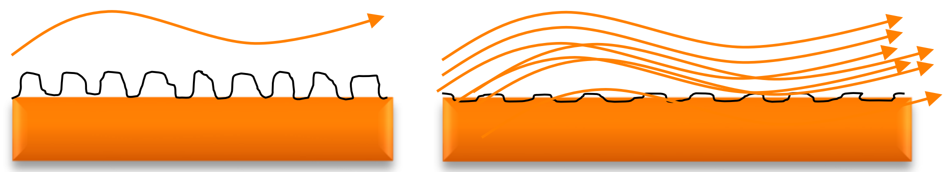
- Excessive growth, which could plug the media system
- Slow mass transfer
- Inadequate mixing or short circuit, resulting in an inefficient use of the media

Background

High organic load

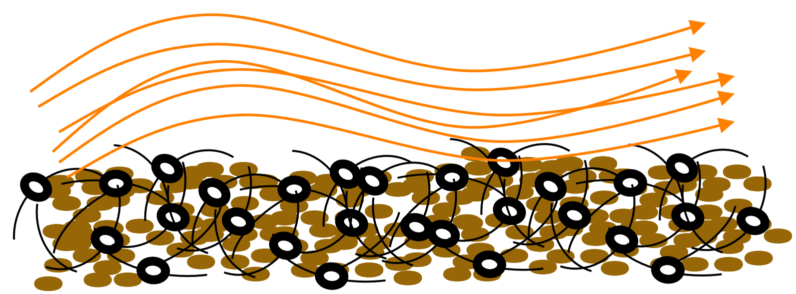
Accumulated high microorganisms on the support, process present oxygen deficit

Increase air flow for improve $k_L A$

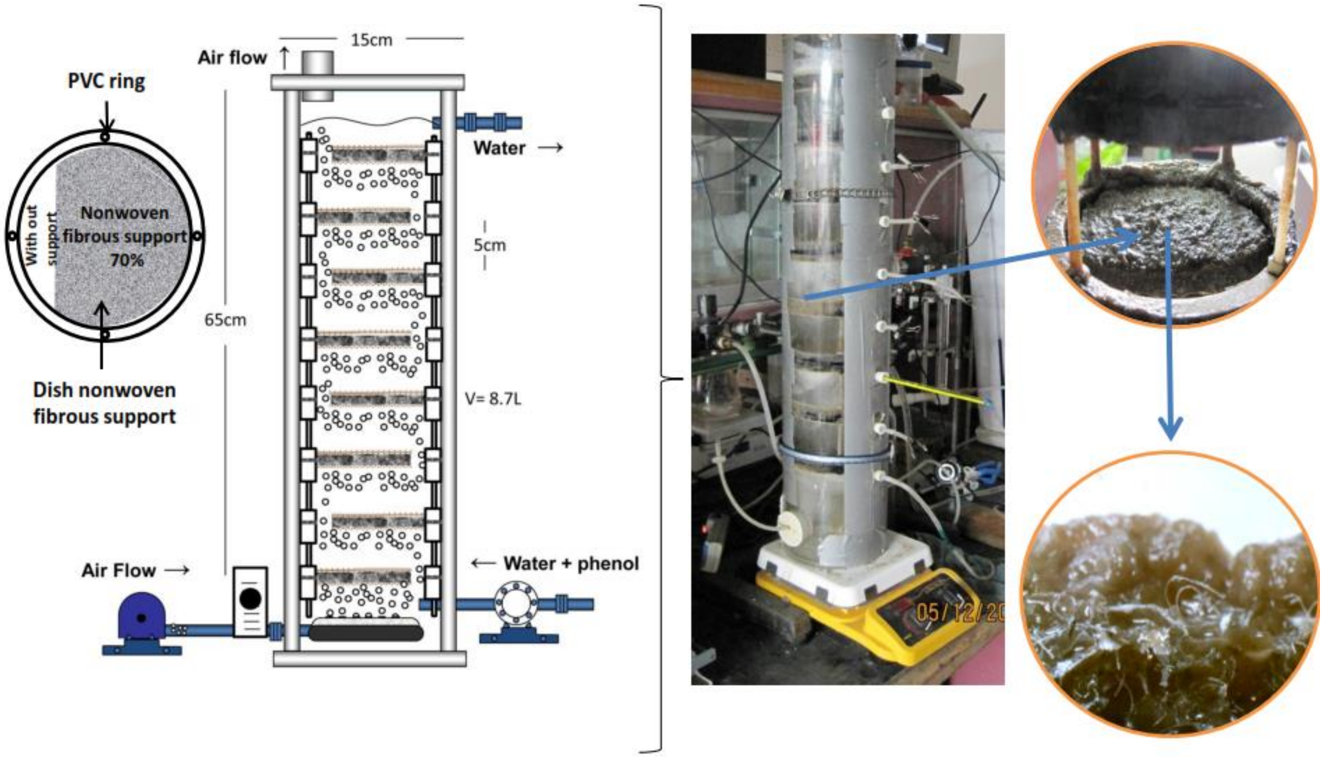


Nonwoven fibrous support.

- **Advantages Nonwoven fibrous support** (Kilonzo, 2010)
- Provide high specific surface area
- Improve cell attachment
- High and constant surface to volume ratio
- High mechanical strength
- High permeability
- Low cost
- Lower mass transfer resistance compared with micro-carrier particles



Background



- The design of this reactor increases the aeration rates, as a result of the reduction of cross section trough which the air is flowing
- The zig-zag air flow inside the reactor increasing the agitation of the liquid
- The nonwoven fibrous support provides the necessary protection to prevent detachment of microorganisms, making possible to operate at higher aeration rates
- The separations of fiber dishes not let the bed clogging

Research

The aim of this work was to study a novel design reactor followed by the evaluation aeration rates increasing in a laboratory scale reactor operating in continuous and discontinuous. Considering the processes involved in the biological degradation (hydrodynamics, mass transfer, and biological reaction) of a model substrate, in order to obtain data, which may be used to describe the operation of this type of reactors, which employ nonwoven fibrous materials as biofilm support.

Methodology

Acclimatization of microorganisms to phenol

↓

Experimental device

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Continuous biofilm reactor operation at different organic load

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Evaluation of biofilm reactor

Mixing time (tm95) in bioreactor	Oxygen mass transfer	Mass transfer L/S	Evaluation of biofilm detachment

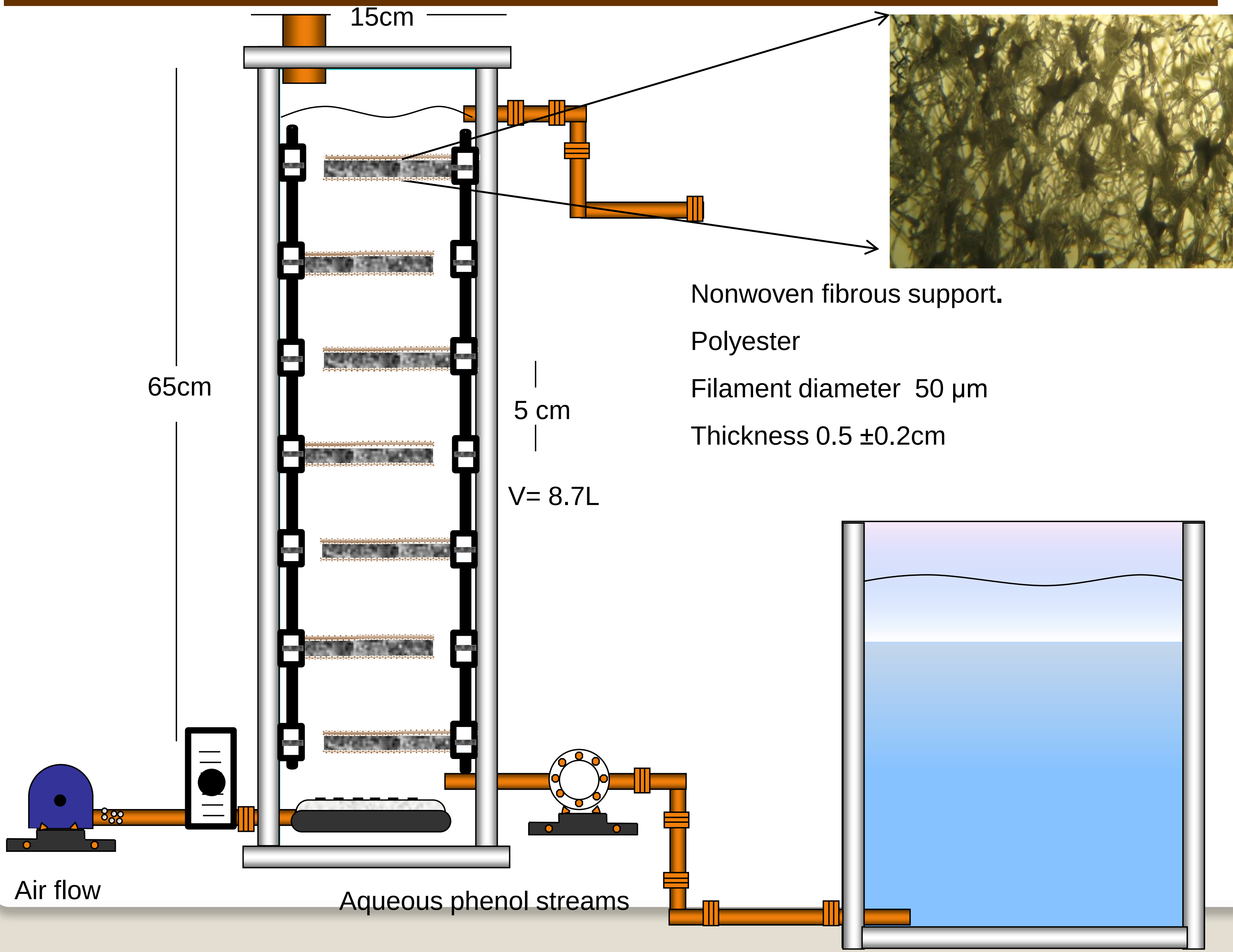
Acclimatization of microorganisms to phenol

Mixed liquor samples were collected from an activated sludge wastewater treatment plant at the UNAM campus. Sludge samples were grown in gradually enriched phenol media, until the microorganism were adapted

Acclimatization of microorganisms to phenol								
Day	**Glucose (mg/L)**	**Phenol (mg/L)**	**Day**	**Glucose (mg/L)**	**Phenol (mg/L)**	**Day**	**Glucose (mg/L)**	**Phenol (mg/L)**
1	281	**0**	**9**	120	**72**	**11**	**80**	**90**
2	261	**9**	**6**	181	**45**	**12**	**60**	**99**
3	241	**18**	**7**	161	**54**	**13**	**40**	**108**
4	221	**27**	**8**	141	**63**	**14**	**20**	**117**
5	201	**36**	**10**	100	**81**	**15**	**0**	**126**

PARAMETERS	**METHODS /INSTRUMENTS**	**UNIT**
Phenol	Mkandawire et al. (2009)	mg/L
Total suspended solids (TSS)	2540 B	mg/L
Volatile suspended solids (VSS)	2540 D	mg/L
pH	Orion™ 2-Star pH meter (Thermo Orion, USA).	---
Dissolved oxygen	HANNA HI 9143 dissolved oxygen electrode	mg/L

Experimental device



Nonwoven fibrous support.

Polyester

Filament diameter 50 µm

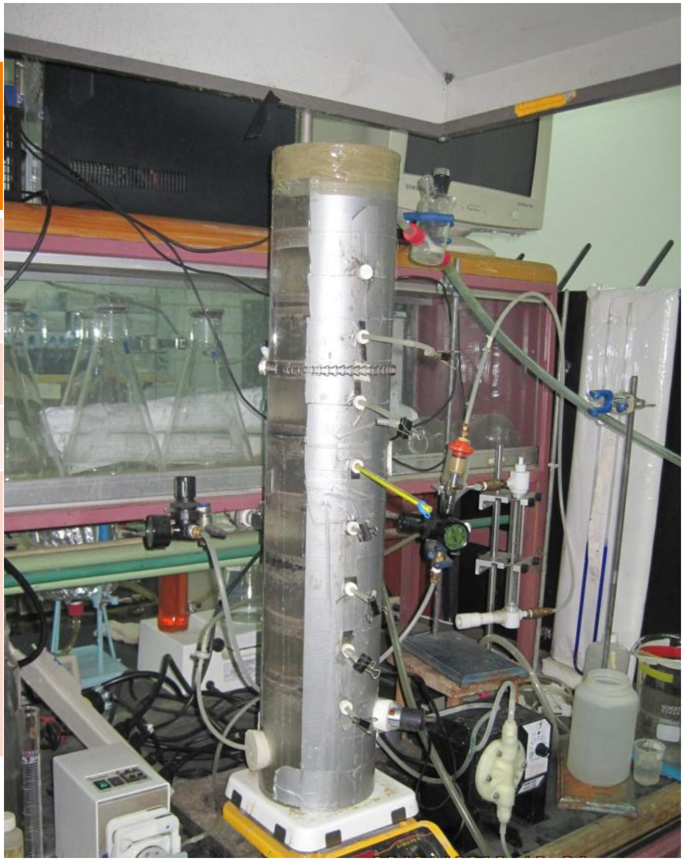
Thickness 0.5 ±0.2cm

Continuous biofilm reactor operation at different organic load

Operation (d)	Organic load (g/m^2 d)	Phenol concentration (mg/L)
13	13	100
13	24	300
18	50	500
20	100	1000

Operating Conditions

Hydraulic Residence time 8.0 h, pH 7.4, temperature 21°C, Air flow 16.60 L/min, Liquid flow 1.05 ± 0.1 L/h.



Mixing time (tm95) in bioreactor

Mixing

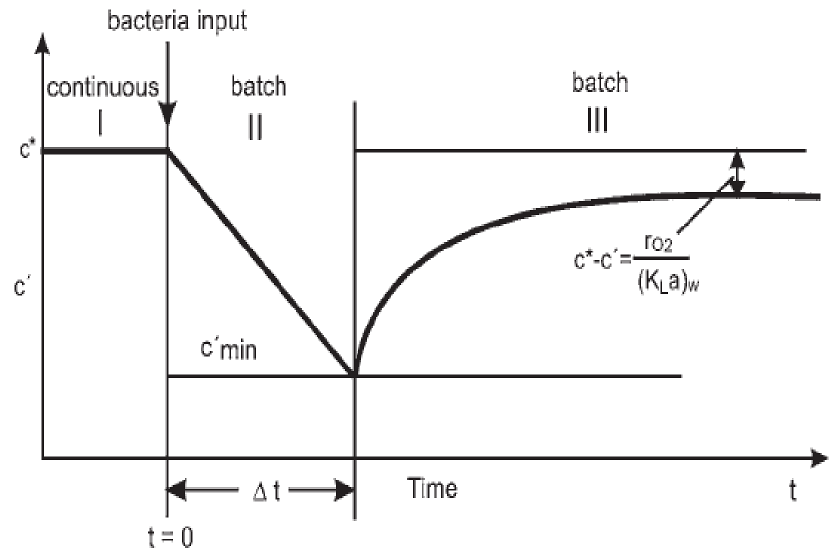
The flow regime inside of the reactor was measured by methylene blue dye pulse injection. The mixing times were evaluated at four different aeration rates values (Ug) 0,021 0.064, 0.080 and 0.096 m/s).

Oxygen mass transfer (*Mass transfer (G/L)*)

Dynamic method (ASCE*, 2006)

Mass transfer (G/L)

The oxygen transfer into the bioreactor was determined by the dynamic method In eight experiments were measured the dissolved oxygen every three seconds, and the values of oxygen transfer coefficient (k_La) were calculated at different aeration rates (Ug0.009, 0.021, 0.050, 0.064, 0.080, 0.096, 0.112 and 0.129 m/s).



*American Society of Civil Engineers

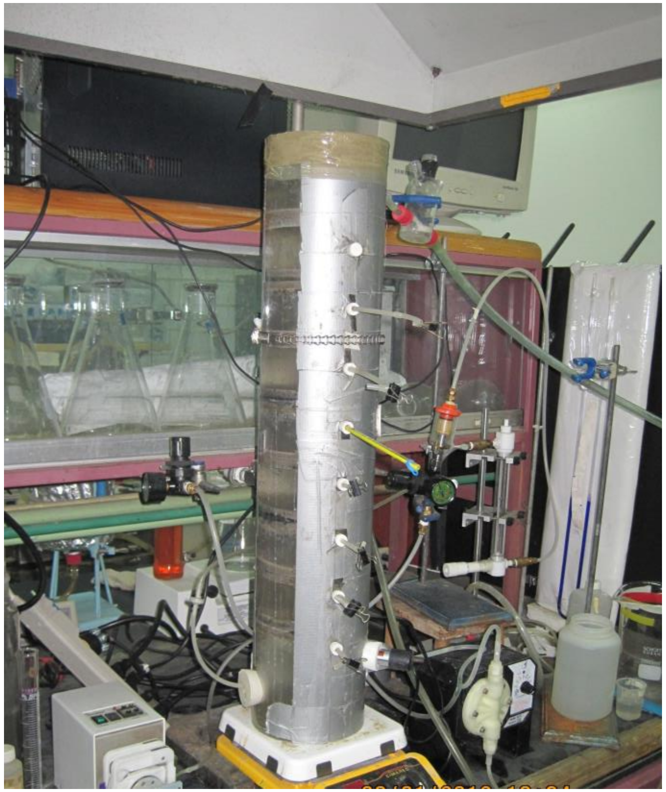
Mass transfer (L/S) and evaluation of biofilm detachment

Mass tranfer

The system was operated in batch, considering four aeration rates (0.080, 0.096, 0.112 and 0.129 m/s), with 100 mg phenol/L as a contaminant to evaluate the air flow effect in the apparent substrate consumption rates. Also, the external mass transfer coefficients (kc) were calculated using the Aquasim model

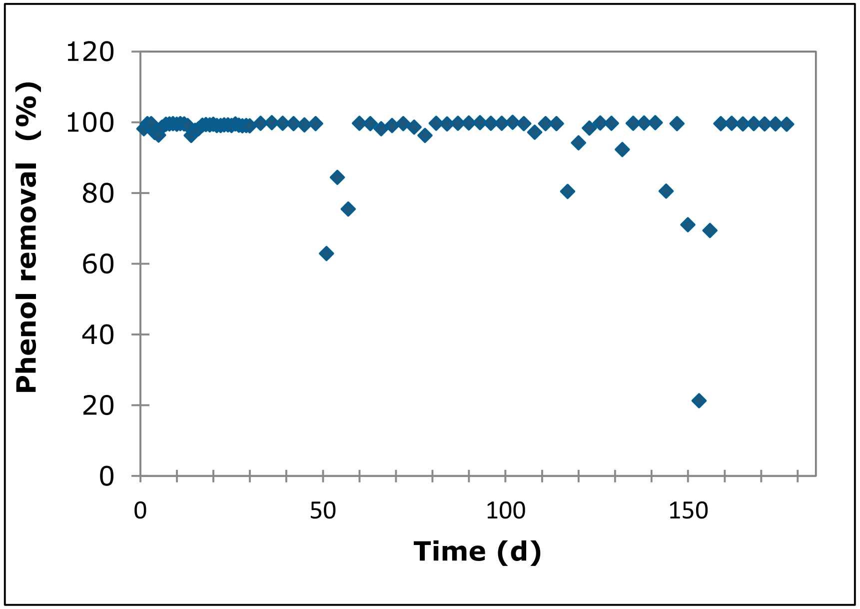
Biofilm detachment

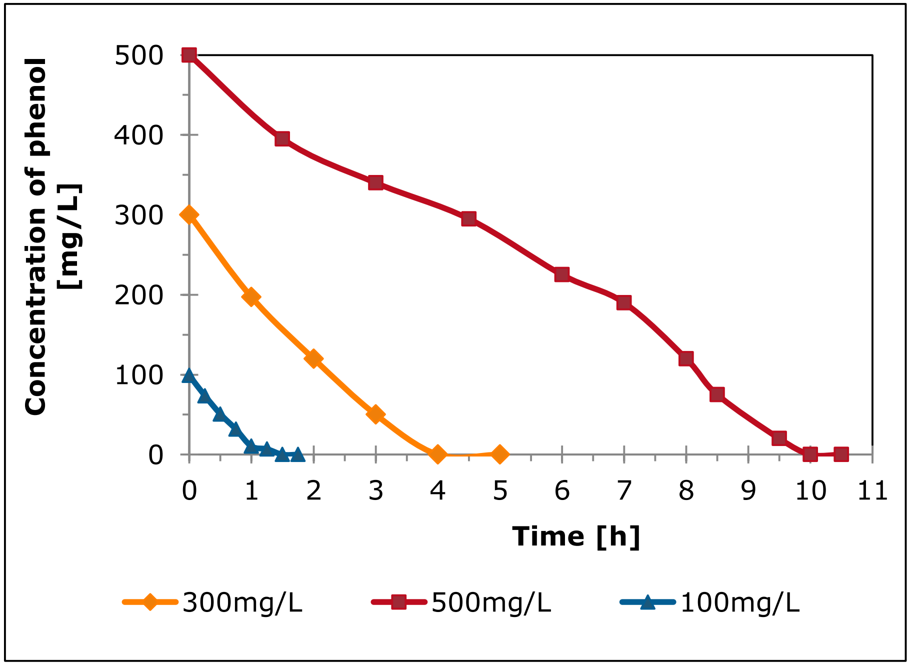
The biofilm detachment was evaluated by total suspend soils (TSS) for each shear stress value in the bulk liquid. The shear stress was calculated considering three different aeration rates (Ug)



Results and discussion

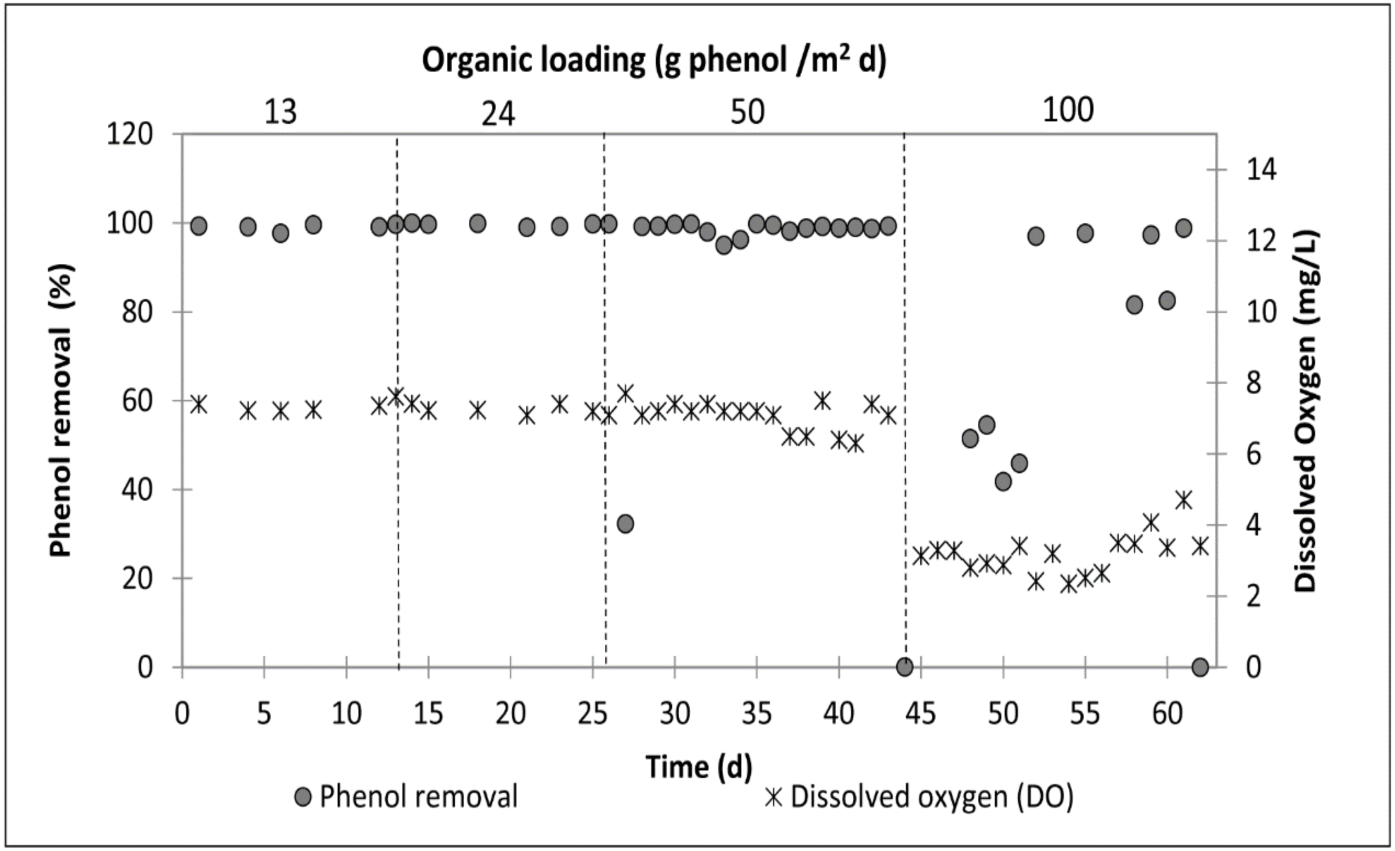
Acclimatization of microorganisms to phenol





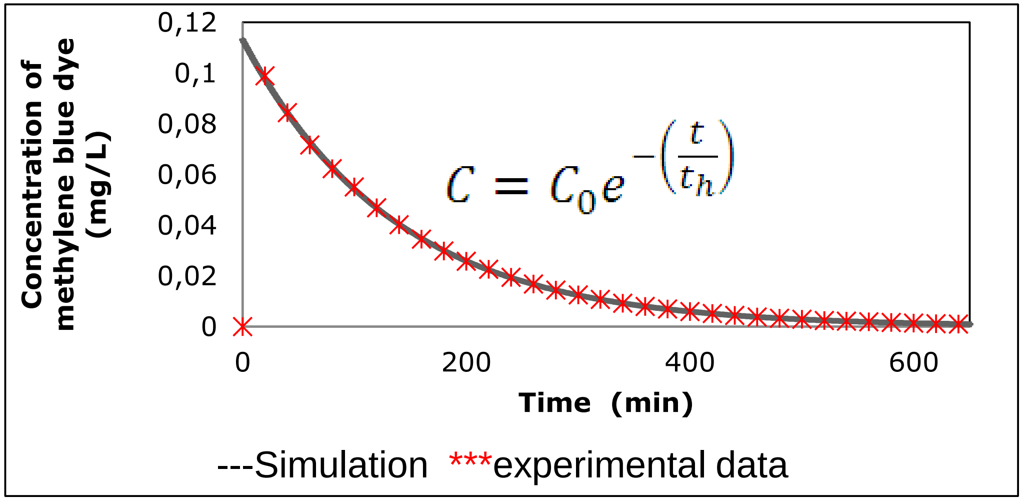
The results obtained from the Aquasim model for the half-saturation coefficient (K_S), 15.47 mg/L, and the maximum growth rate (μ_{Max}), 0.1158 h^{-1},

Continuous biofilm reactor operation at different organic load



Evaluation of biofilm reactor (Mixing time (tm95))

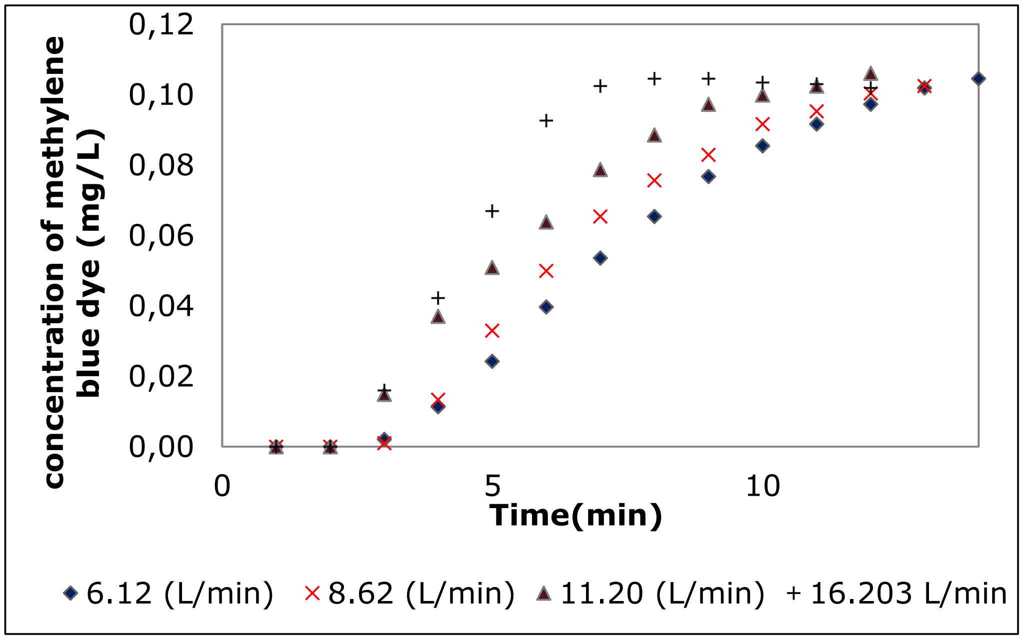
The reactor behaved as a completely mixed flow; ***(Air flow 11.20 L / min)***



Complete mixing system

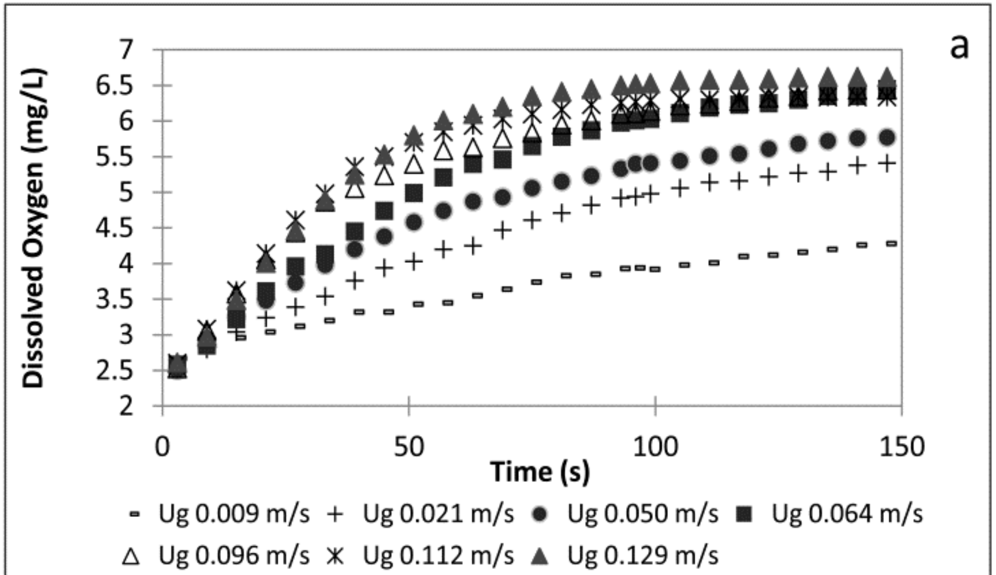
HRT 2.25 h

$R^2 = 0.9993$



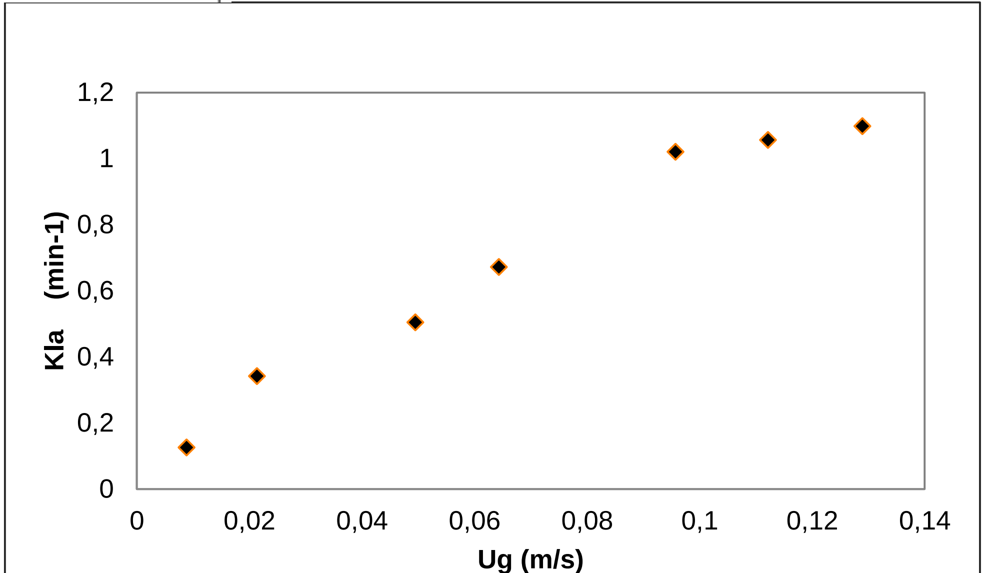
Air Flow (L/min)	Mixing time (min)
6,12	13
8,26	12
11,10	10
16,64	7

Evaluation of biofilm reactor (Oxygen mass transfer)

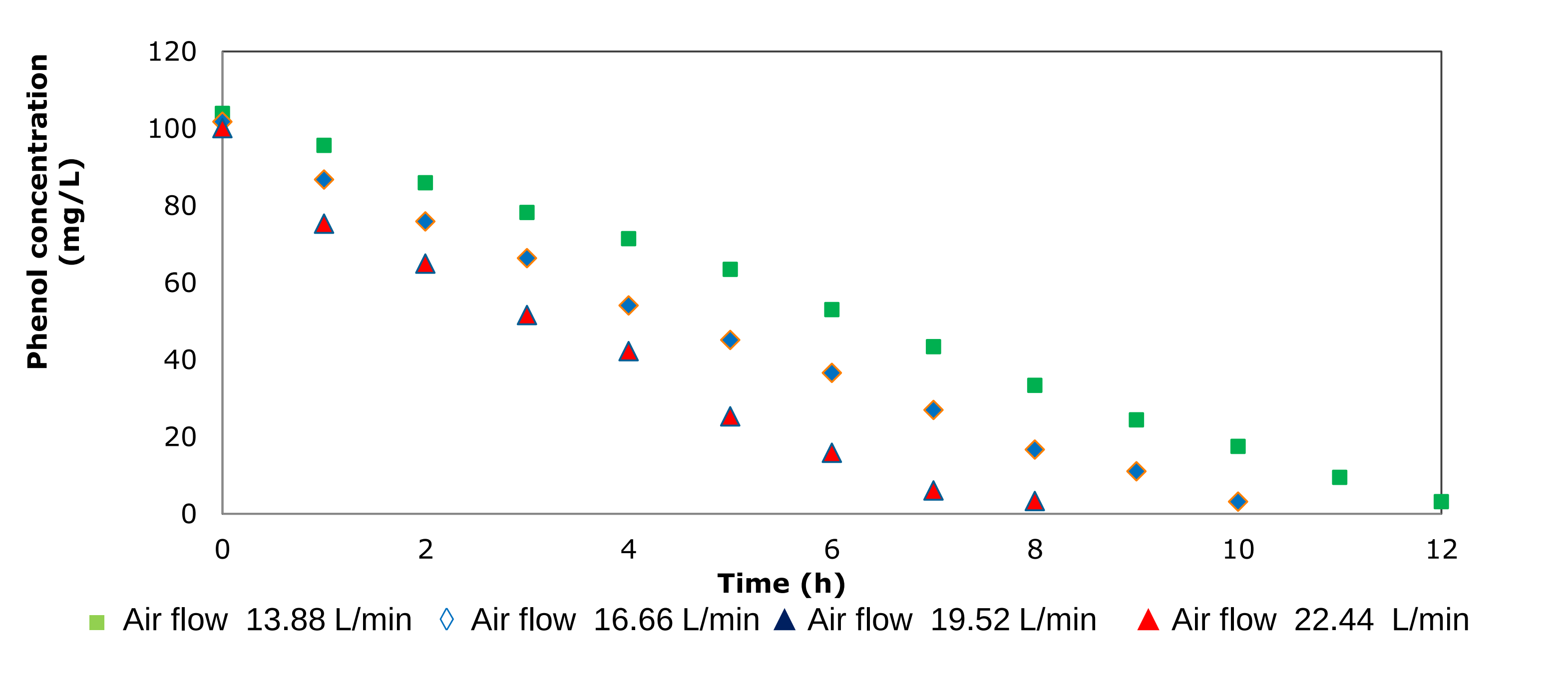


Experimental data of the biological reactor dissolved oxygen at different values air flow

Air flofw (L/min)	U_g m/s
1.53	0.009
8.61	0.021
11.20	0.050
13.66	0.064
*16.66	0.096
19.51	0.112
22.44	0.129



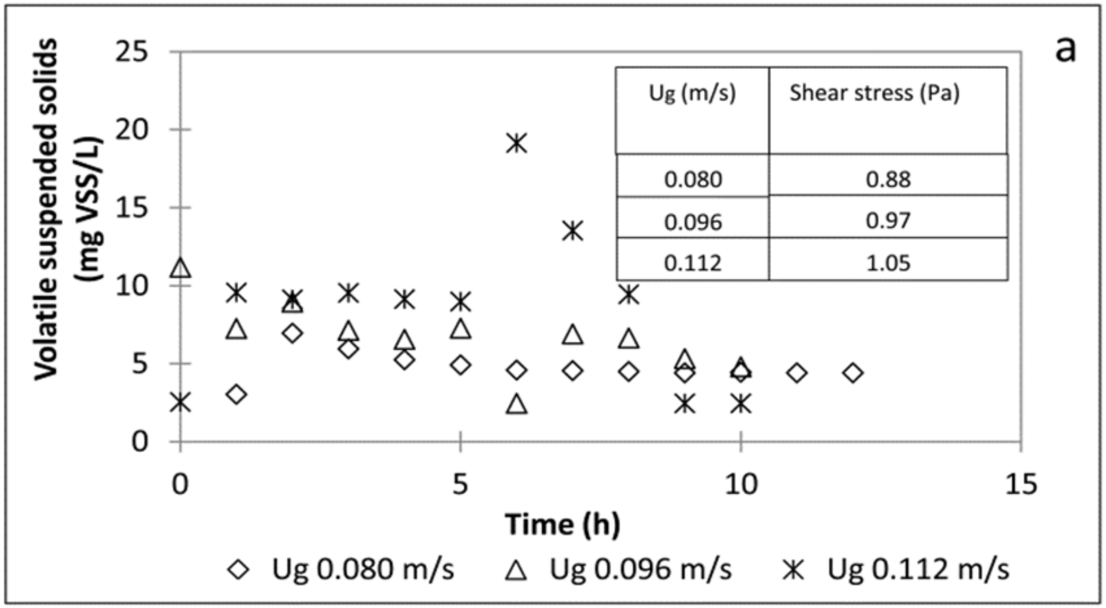
Evaluation of biofilm reactor (Mass transfer L/S)

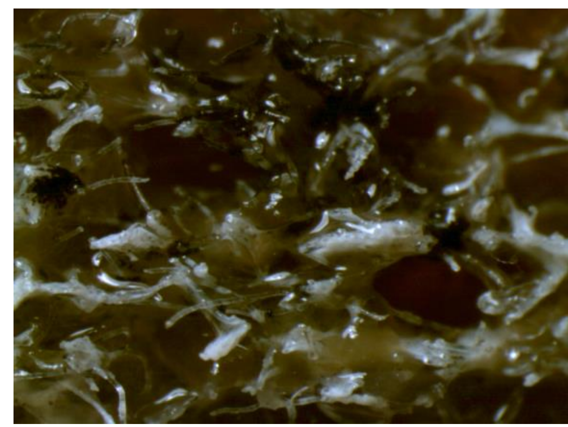


Air flow(L/min)	Apparent reaction rate (mg phenol /Lh)	Kc (m/s)
13.88	8.37	3.67E-04
16.66	10.34	4.81E-04
19.52	11.78	2.68E-03
22.44	11.79	2.68E-03

Mass transfer (L/S), modeling of the batch biofilm reactor using the Aquasim (zero order)

Evaluation of biofilm reactor (Evaluation of biofilm detachment)





Conclusion

This no-woven biological reactor can operate at high organic loads improving the apparent substrate consumption rate, the external mass transfer and detachment due to the novel design that includes the use of nonwoven material as support. As a result, this work provide information and solutions to some of the commonly encountered problems in traditional biofilm reactor

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Thank you for your attention

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