EXPERIMENTAL INVESTIGATION AND MODELLING OF ALUMINUM ADSORPTION BY *Fucus vesiculosus*

MOREIRA, V. R.[1], LEBRON, Y. A. R.[1], FOUREAUX, A. F. S.[2] & SANTOS, L. V. S. [1,2]

[1] Chemical Engineering Department, Pontifical Catholic University of Minas
[2] Department of Sanitary and Environmental Engineering, Federal University of Minas Gerais
Corresponding author e-mail: victorrznde.eng@gmail.com

EXTENDED ABSTRACT

As a result of accelerated industrial growth and anthropic activities, a diversity of pollutants has been discharged and, therefore, detected in surface water, stimulating the search for low cost and effective treatment options. Algae have already proven its efficiency for a different pollutants' remediation (LEBRON *et al.*, 2019). Therefore, the present study investigated the use of a brown algae sample *Fucus vesiculosus* (*F. vesiculosus*) for its capacity to remediate aluminum in aqueous solution. The heavy metal could be introduced to the human body by inhalation, ingestion and dermal contact by different sources of exposure, for example surface and drinking water. High amounts of aluminum in the human body showed adverse effects on the nervous system resulting in memory loss, in addition to problems with balance and loss of coordination as demonstrated by Jaishankar *et al.* (2014).

F. vesiculosus morphology and composition was assessed by scanning electron microscopy and infrared. Batch experiments were conducted in media composed with 5 $g.L^{-1}$ of adsorbent, pH 6, temperature of 303 K and different concentrations of aluminum (50 – 2000 $mg \cdot L^{-1}$) for 4 h and 250 rpm in an orbital shaker. The metal concentration was determined by a flame absorption spectrometer. Lastly, the adsorption capacity was estimated. Langmuir, Freundlich and Sips isotherms models were chosen to estimate the equilibrium parameters, which were estimated with Origin 2018 (OriginLab) software, by minimizing the chi-square function. The isotherm model's fit was evaluated by comparing predicted response with experimental responses, using the determination coefficient (R^2) and chi-square statistic (χ^2).

Adsorbents such as algae generally have a complex infrared spectrum resulted from the different macromolecules that make up their structure. Still, it is possible to obtain important information about the material composition. In the infrared spectrum (Fig. 1(a)), the 2926 cm^{-1} band corresponds to (C–H) bonds, while the bands at 1638 cm^{-1} correspond to carbonyl groups (C=O), present in aldehydes, ketones and carboxylic acids. In the region of 1408 cm^{-1} are the primary ($N–H_2$) and secondary amines (N–H), associated with the presence of proteins and lipids. The loaded spectra had an increase in the transmittance, this phenomenon can be associated with the adsorbate interaction with previously available functional groups. SEM images (Fig. 1(b)) showed an adsorbent with non-uniform morphology and surface, which could favor the biosorption process since its intensity is directly related to the available surface area.

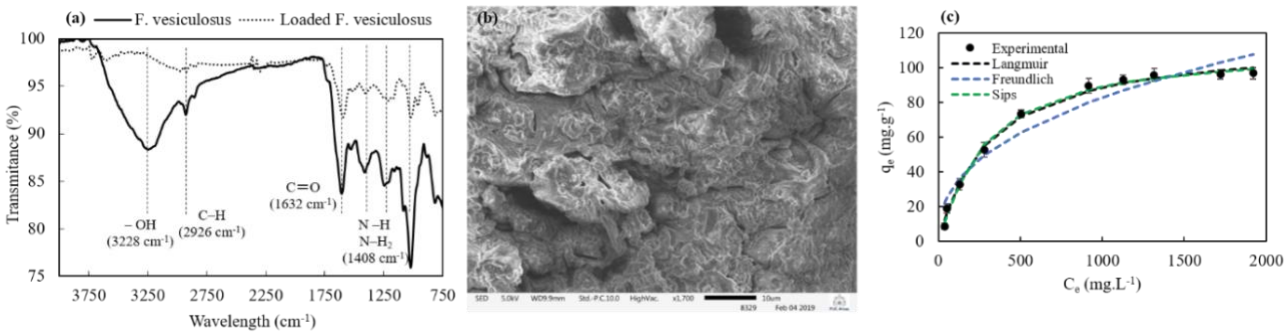

Figure 1 – (a) Infrared spectrum before and after the adsorption process (b) *F. vesiculosus* surface morphology; (c) adsorption isotherms.

The experimental and fitted biosorption isotherms are shown in Fig. 1(c). The adsorption isotherms have a convex shape, which can be classified as type I isotherm according to Blázquez *et al.* (2010). This shape is associated with monomolecular layer adsorption of non-porous or microporous sorbents. The parameters obtained from the Langmuir, Freundlich, and Sips are shown in Table 1. The maximum adsorption capacity in the Langmuir model is 116.3 mg·g^{-1}, in good agreement with the experimental one ($q_{max,exp}$), the same applies to the Sips model. In the last mentioned, the m_T values approach one. In this case Sips equation is reduced to the Langmuir equation, reinforcing that the best biosorption mechanism is the one described by the Langmuir equation - the adsorption process is based on a monolayer formation over a homogeneous adsorbent surface, with no difference in binding energy for each active site.

Table 1 - Isotherm parameters obtained by nonlinear estimation.

Langmuir		Freundlich		Sips	
q_{mL} (mg·g^{-1})	116.33 ± 2.91	K_F[a]	5.16 ± 1.88	q_{mS} (mg·g^{-1})	110.66 ± 4.90
K_L (L·mg^{-1})	0.003 ± 0.001	n	2.49 ± 0.32	K_S (L·g^{-1})	0.003 ± 0.001
R^2	0.993	R^2	0.939	m_T	1.11 ± 0.09
χ^2	2.21	χ^2	15.31	R^2	0.995
				χ^2	2.20
$q_{max,exp}$ (mg·g^{-1})	96.81 ± 5.81				

[a] Expressed in mg$^{1-1/n}$.L$^{1/n}$.g^{-1}

KEYWORDS: Algae; Heavy Metals; Wastewater.

REFERENCES

LEBRON, Y. A. R. et al. Biosorption of methylene blue and eriochrome black T onto the brown macroalgae *Fucus vesiculosus*: equilibrium, kinetics, thermodynamics and optimization. *Environmental technology*., (*just accepted*), 2019.

JAISHANKAR, M. et al. Toxicity, mechanism and health effects of some heavy metals. *Interdisciplinary toxicology*., v. (7), p. 60-72, 2014.

BLAQUEZ, G. et al. Equilibrium biosorption of lead (II) from aqueous solutions by solid waste from olive-oil production. *Chemical engineering journal*., v. (160), p. 615-622, 2010.