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Adsorption study of metribuzin pesticide on fungus *Pleurotus mutilus*

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A B S T R A C T

The aim of the present work is the valorization of the biomass *Pleurotus mutilus* fungal biomass in the biosorption of metribuzin pesticide. The present study constitutes of two principal parts. The first part includes physical pretreatment and structural characterization of the biomass. In the second part, different parameters likely to have an influence on the biosorption capacity of metribuzin such as biomass, particle size, biosorbent content, agitation, temperature, pH and metribuzin concentration were studied. The results of adsorption experiments obtained for synthetic water were convincing, and an adsorption rate of metribuzin of approximately 70% was reached for the following optimum conditions: particle size [250–400 μm], pH = [2–3], biomass content 3 g, agitation of 250 rpm, temperature of 25 °C, and initial concentration of metribuzin = 200 mg L^{-1}.

1. Introduction

The wide use of pesticides gives rise to serious ecological problems, owing to their negative environmental effects (Cohen et al., 1984; Thiemann et al., 1991; Behloul et al., 2013). The contamination of surface and ground water by pesticides is a matter of concern for the scientists over a period of years.

Metribuzin is one of the most organometallics herbicides used in Algeria as well as all over the world. This pesticide has largely substituted the chlorinated hydrocarbons due to their lack of affinity for lipid tissues and their comparative non persistence in soils (Tireche et al., 2012; Réévaluation de la Metribuzine, 2005; Kitous et al., 2012, 2016).

Metribuzin is a synthetic organic compound. It is a selective triazinone herbicide used primarily to discourage the growth of broad leaf weeds and annual grasses among vegetable crops and turf grass. Metribuzin accomplishes this by inhibiting electron transport in photosynthesis. Common uses include application to soybeans, potatoes, alfalfa, sugarcane, barley, and tomatoes (Papadakis and Papadopoulou-Mourkidou, 2002; Tomlin, 2000).

Many processes have been proposed for metribuzin removal from water and groundwater. Electrochemical treatment, ultraviolet oxidation, electro-activated granular carbon, and membranes techniques are among the most commonly used methods; each has its merits and limitation in application (Plakas et al., 2006; Ikeura et al., 2011; Yahiaoui et al., 2011).

The biosorption is currently considered as an alternative process for pesticide pollutant elimination (Mushtaq et al., 2016).

Different types of adsorbents like plants, activated carbon, carbon cloth, bacteria, straw (Lan et al., 2004) have been used in the case of metribuzin removal. The present study proposes the use of a new biosorbent, *Pleurotus mutilus* (mycelial basidiomycetes) for the treatment of water charged with metribuzin pesticide. The biomass constitutes a solid waste the SAIDAL, pharmaceutical industry, unit of Medea (Algeria) and proved its efficiency for the treatment of waters charged with heavy metals (Bal et al., 2003).

In the present study biosorption of metribuzin on *Pleurotus mutilus* is investigated. Characterization of the biosorbent structure was done using infrared spectroscopy. The biosorption tests were carried out in a batch mode. Several parameters like particle size, biosorbent content, agitation, temperature, and pH were optimized.

2. Materials and methods

Metribuzin ($C_8H_{14}N_4OS$) is a white crystalline solid with a melting point of 126 °C. Pure metribuzin is soluble in water up to 1200 ppm (1.2 g/L). Metribuzin has a slight sulfurous odor. It is reported to have a vapor pressure between 5 and 10 mm Hg at 20 °C

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Table 1
Physicochemical characteristics of *Pleurotus mutilus*.

Granulometry (μm)	0–160	160–250	250–400	400–625
Moisture (%) $\pm 10^{-2}$	2.89	2.81	2.74	2.62
d_r	1.51	1.43	1.4	1.38
d_{app}	0.32	0.38	0.41	0.42
Porosity	0.62	0.63	0.66	0.68
V.P.T (cm^3/g)	2.46	1.93	1.72	1.65

and a density of 1.28 between 4 and 20 °C (Deng et al., 2007; EPA, 2003).

The Metribuzin concentration in water solution has been determined at a wave length of 293 nm using a spectrophotometer (SHIMADZU, 1240CE (Japan)).

A residual solid waste of the *pleuromutilin* (antibiotic) production was obtained from SAIDAL pharmaceutical industry unit located in Medea (Algeria). It consists of non-living basidiomycetes; *Pleurotus mutilus* (noted P. mutilus). The biomass wafers were cleaved and led out on big trays for drying. After drying, the biomass was washed several times using distilled water. It was then re-dried in air for 24 h and was baked at 50 °C. The clean biomass was grounded mechanically and sifted to obtain powder of varying particle sizes, viz: [0–160] μm, [160–250] μm, [250–400] μm, and [400–625] μm.

The solution pH was adjusted to the required value using 0.1 M hydrochloric acid and 0.1 M sodium hydroxide.

2.1. Physicochemical and structural characterization of biosorbent

The main physicochemical characteristics are given in Table 1.

The FTIR spectra of the biosorbent were recorded on KBr discs using a Shimadzu 8400 (400–4000 cm^{-1}) instrument.

2.2. Metribuzin biosorption kinetic

Experiments were carried out in batch mode using a reactor of 50 ml volume. A known mass of biosorbent was maintained in contact with metribuzin solution. The kinetic curves describing the biosorption of metribuzin were determined by measuring the pesticide concentration. The metribuzin concentration in water solution was determined using the spectrophotometer, SHIMADZU, 1240CE (Japan) at wave length of 293 nm (wave length at which the measured absorbance has been maximum).

The pollutant removal efficiency (X) was calculated according to the equation:

$$X = (C_0 - C)/C_0 \quad (1)$$

where, C_0: is the initial pesticide concentration (mg L^{-1}), C is the residual pesticide concentration in the solution. In order to optimize the biomass quantity requisite for a pesticide maximal fixation, the ratio effect (sorbent mass/solution volume) on the pesticide sorption capacity was investigated.

2.2.1. Effect of particle size

The best particle size range is the one that presents a compromise between the biosorption capacity and the mechanical behavior. Biosorption assays were achieved under the following conditions: an initial concentration (C_0) = 200 mg L^{-1}, a solution volume of 50 mL, an initial pH: pH_i = 4, a stirring speed (w) = 250 rpm, a temperature (T) = 25 °C, a biosorbent content = 2 g, and for various particle sizes:[0–160 μm], [160–250 μm], [250–400 μm], and [400–625 μm].

2.2.2. Effect of biosorbent content

In order to optimize the biomass quantity requisite for a maximal fixation of pesticide, the effect of the ratio: (biosorbent mass/solution volume) on the metribuzin biosorption capacity was investigated. The particle size ranged from 250 μm to 400 μm. C_o = 200 mg L^{-1}, the solution volume was 50 mL pH_i = 4. The stirring speed w = 250 rpm. The temperature T = 25 °C and the biosorbent content varied from 1 g to 4 g.

2.2.3. Effect of pH

The pH plays an important role in the biosorption phenomena.

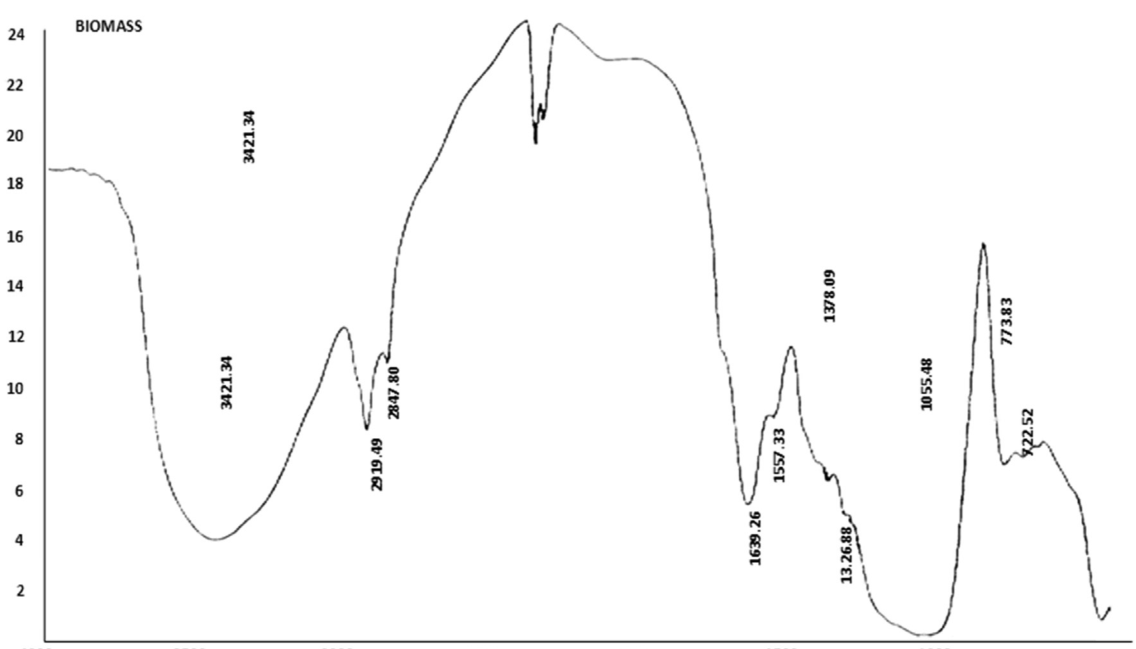

Fig. 1. FT-IR spectra for the *Pleurotus mutilus* fungal biomass.