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Toxicity and absorciometric decay of textile dyeing effluent with reactive dyestuff RB21 submitted to electron beam irradiation

C. G. Melo[1], J. M. Rosa[1,2], S. I. Borrely[1], M. C.C. Pereira[1]

[1]*camila.gomes.melo@hotmail.com,*
Av. Professor Lineu Prestes, 2242
05508-000 São Paulo, SP, Brazil

[2] *jotarosa@hotmail.com*
Rua Correia de Andrade, 232
03008-020 São Paulo, SP, Brazil

1. Introduction

The textile sector stands out for its importance in the global economy and for the high consumption of water in its production processes, mainly in processing. This results from the need for a reaction in an aqueous medium between the fiber and the organic and inorganic inputs [1, 2].

The generated wastewater has high absorciometric rates, due to the hydrolyzed dyestuff present in the dyebath, and several inputs with high solubility and low degradability. Consequently, a colored effluent that is potentially toxic to aquatic biota is generated [1].

The objective of this study was to evaluate the absorciometric index and the toxicity of the textile dyeing effluent, with the Reactive dyestuff Blue 21 (RB 21), before and after the treatment by electron beam irradiation (EBI).

2. Methodology

In this study, an ideal textile effluent was produced on the premises of the Faculdade de Tecnologia do SENAI "Antoine Skaf", based on the of Response Surface Methodology (RSM) tool to obtain the optimized dyeing.

The effluent was neutralized and irradiated in a Dynamitron type electron accelerator, with energy fixed at 1.4 MeV, constant displacement speed of 6.72 m min^{-1}, variable beam current, and doses of 5 kGy, 7.5 kGy, 10 kGy and 15 kGy. This facility belongs to Centro de Tecnologia das Radiações (CETER/IPEN).

The acute toxicity of these samples was analyzed at the Laboratório de Ensaios Biológicos e Ambientais (LEBA/ IPEN), before and after irradiation, through ecotoxicological tests with the *Daphnia similis* microcrustacean [3], in which the organisms were exposed to different concentrations of the effluent at standardized condition and for 48 hours. After the exposure period, the immobility of the daphinids was verified and the results were expressed in EC50 (%), based on the estimate obtained by the Trimmed Spearkman - Karber method, and Toxic Unit (TU).

$$TU = \frac{100}{EC50} \quad (1)$$

From the Toxic Unit values of the raw and irradiated samples, it is possible to determine the effectiveness of the treatment of irradiation by electron beam to reduce the acute toxicity (TR) of the effluent under study.

$$\%TR = \left(\frac{TU_0 - TU_f}{TU_0}\right) * 100 \quad (2)$$

The Absorciometric Decay (AD) value of the raw and irradiated samples was obtained by visible spectrophotometry (Konica Minolta spectrophotometer, model CM-3600d), at the Laboratório de Química Têxtil, at SENAI premises, obtaining the maximum absorbance values. The calculation and value of AD (%) was obtained by the equation.

$$A_D = \left[\frac{A_{0-A_f}}{A_0}\right] x100 \quad (3)$$

In wich:
A_0: Initial absorbance (raw sample)
A_f : Final absorbance (irradiated sample).

3. Results and Discussion

Acute toxicity assays were performed on untreated and irradiated effluent samples at doses of 5 kGy, 7.5 kGy and 10 kGy. The median effective concentration of the effluent that caused an effect on 50% of the microcrustaceans in each dose, as well as the Toxic Unit values, are shown in Table I.

Table I: Values of EC50 and TU in raw and irradiated samples

Dose (kGy)	$EC50_{48h}$ (%)	TU
0	4.39 (3.72 - 5.15)	22.78
5.0	5.74 (4.81 - 6.86)	17.42
7.5	13.81 (11.52 - 16.56)	7.24
10.0	12.87 (11.58 - 14.31)	7.77

The raw sample was about 215% more toxic than the best sample treated by EBI, at a dose of 7.5 kGy, which presented a toxicity reduction of 68.22%. The 5 kGy and 10 kGy doses showed a reduction in toxicity of 23.53% and 65.89%, respectively. Garcia et al. (2020) [4] also obtained a toxicity reduction above 60% when using the EBI treatment to reduce the toxicity of the analyzed textile effluent containing the Reactive dyestuff Red 239.

The 10 kGy dose showed a small decrease in the EC 50% value compared to the 7.5 kGy dose. This fact was also observed in a study carried out by Borrely et al. (2016) [5] with the Reactive dyestuff Blue 222, in which the sample irradiated with 5 kGy obtained 13.16% of EC 50 and with the dose of 10 kGy it obtained 10.79% of EC 50 values.

The color reduction was analyzed in the samples: raw, 7.5 kGy, 10 kGy and 15 kGy, as they resulted in a significant visual color reduction (Figure 1).

Figure 1: Samples for absorciometric decay analysis

The samples were then analyzed by visible spectrophotometry in the range of 620 nm, whose maximum absorbance values are shown in Figure 2.

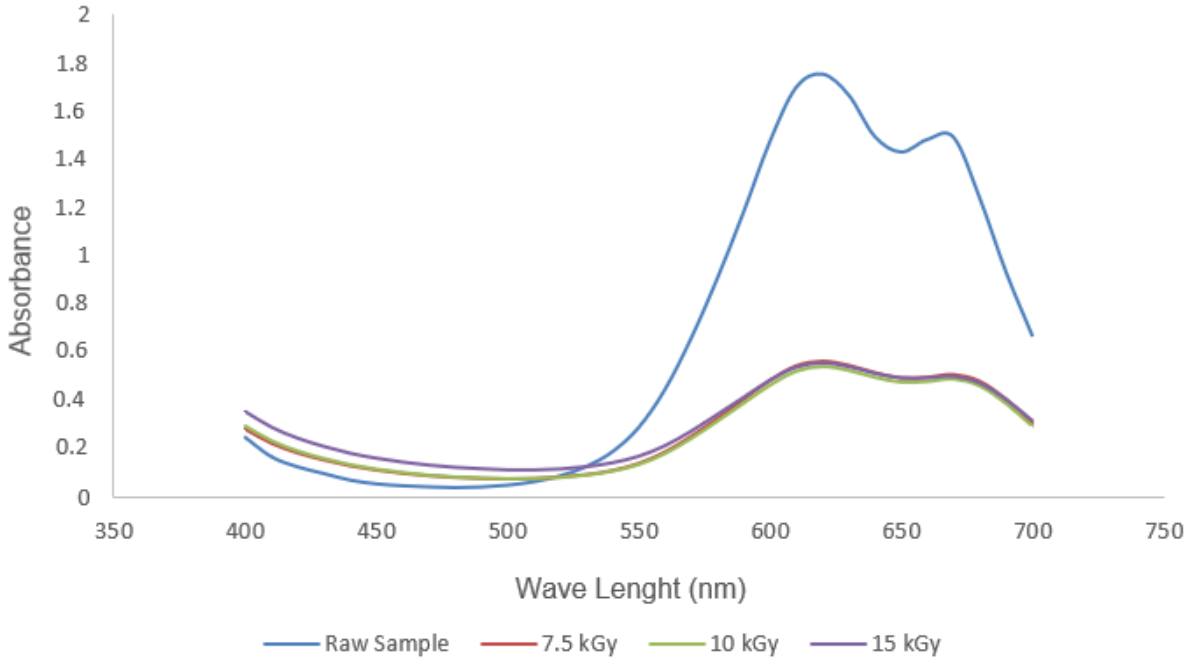

Figure 2: Reading of sample concentrations

The EBI in the effluent provided an absorciometric decay directly proportional to the increase in radiation dose up to a dose of 10 kGy, with a reduction of 69.13%. The color reduction of the effluent containing the RB 21 was also analyzed by Duy et al. (2019) [6] through the application of EBI at doses of 5 kGy, 10 kGy and 15 kGy, in which they obtained a color reduction of 36%, 52% and 69%, respectively, corroborating the results obtained in this study. The same treatment was applied by Borrely et al. (2019) [7] at doses of 5 kGy

and 10 kGy, to analyze the absorciometric decay of textile effluent with Reactive Dyestuff Yellow 160, achieving results of 75% for the dose of 5 kGy and 90% for the dose of 10 kGy.

4. Conclusions

The electron beam irradiation technology may be a viable method for the decolorization of textile dyeing effluents, as well as was effective for the reduction of 69% of the effluent containing RB 21, under the conditions of the study, at 10 kGy. Regarding toxicity, the greatest reduction obtained during the study was 68% with the 7.5 kGy dose.

The study demonstrates the importance of analyzing both the dyeing effluent color and toxicity, as there are numerous inputs and types of dyes available on the market that lead to different interactions and consequences to the receiving water body and aquatic biota.

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