BOD & COD REDUCTION FROM TEXTILE WASTEWATER USING BIO-AUGMENTED HDPE CARRIERS

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Textile wastewater effluents are considered one of the most polluting sources, among all industrial sectors, in terms of both effluent volume and composition, with high BOD and COD values. Biochemical Oxygen Demand (BOD) represents the amount of oxygen consumed by bacteria and other microorganisms in decomposing organic matter under aerobic conditions. Chemical Oxygen Demand (COD) represents the measurement of the oxygen required to oxidize soluble and particulate organic matter in water. The main goal of the present study was the investigation in reduction of both BOD and COD concentrations, in a textile wastewater source, using bio-augmented MBBR specific HDPE carriers (composition: 5% talc, 7% cellulose and 88% High-Density-Polyethylene). The HDPE carriers were bio-augmented in an experimental laboratory installation with five fungi microbial strains (either as a mix or individual strain): 3 own microbial isolates (from decaying wood source) and 2 collection strains, namely *Cerioporus squamosus* (*Basidiomycota phylum*) and *Fusarium oxysporum* (*Ascomycota phylum*). Results showed a reduction rate of COD value of 53.45%, of HDPE carriers bio-augmented in the experimental laboratory installation (mix inoculation), and BOD reduction rates between 28% (carriers bio-augmented with isolate #2) and 61% (carriers bio-augmented with *Cerioporus squamosus* strain).

Keywords: BOD, COD, MBBR

INTRODUCTION

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are general indicators of water quality. The biochemical consumption of oxygen represents the amount of oxygen consumed by microorganisms, in a time interval, for the biochemical decomposition until mineralization of the organic substances contained in the water. Chemical oxygen consumption (COD) analysis is designed to measure the maximum amount of oxygen that can be consumed by organic matter in a given water sample. This is important, because when organic pollutants are discharged into the aquatic environment, it will normally take up dissolved oxygen during its subsequent degradation thus reducing the amount of oxygen available for the respiration of fish and other aquatic life (Cazaudehore *et al*., 2019). Chemical oxygen consumption is an important parameter for water quality because, similar to biochemical oxygen consumption (CBO), it provides an index to assess the effect that discharged wastewater will have on the environment (Jouanneau *et al*., 2013). Higher CCO levels mean a higher amount of oxidizable organic compounds in the sample, which will reduce the level of dissolved oxygen (OD). A reduction in dissolved oxygen can lead to anaerobic conditions, which are detrimental to aquatic life forms. Often, COD analysis is used to estimate BOD (Biological Oxygen Demand) values, between these 2 indicators existing strong correlations (Zhu *et al*., 2018).

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MATERIALS AND METHODS

Treatment Installation and Wastewater Source

Wastewater treatment was carried out on a previously developed laboratory treatment installation, designed for High Density Polyethylene carriers bio-augmentation, which allows continuous media aeration (Figure 1).

Figure 1. Experimental installation

To demonstrate the efficiency of the experimental installation, samples of wastewaters were taken from the wastewater storage basin of INCDTP Bucharest, water resulted from specific technological processes, without any applied processing step.

HDPE Carriers Bio-Augmentation

Polymeric carriers with 5% talc, 7% cellulose and 88% HDPE composition were used in bio-functionalization experiments in the experimental treatment installation. Bio-augmentation experiments were carried with five microbial strains, three decaying wood isolates (T1, T2 and T3), and two collection isolates: *Cerioporus squamosus* and *Fusarium oxysporum*. Preliminary bio-augmentation of the HDPE carriers was carried out on each batch, in a volume of 12L (final volume), with the addition of liquid medium based on potato extract and dextrose. In case of COD analysis, the carriers were functionalized with a volume of 500mL of mix inoculum from all 5 selected strains (100mL of inoculum for each strain). For BOD analysis, the carriers bio-augmentation process was performed individually on each of the five selected microbial strains. The preliminary bio-augmentation process was carried out for 20 days, at 28^{o}C, with continuous aeration, in a Lovibond thermoreactor.

BOD Method

BOD analysis was carried out on a BOD Direct (Hach Lange) equipment, at 5 days. The analysis is performed in sealed bottles, in which the incubation is performed at the specified temperature for 5 days. Dissolved oxygen is measured initially and after incubation, and BOD value is calculated from the difference between the initial and final DO (Kolář *et al*., 2005). Because the initial DO is determined shortly after dilution, all oxygen uptake that occurs after this measurement is included in the CBO measurement. To ensure adequate biological activity, the pH of the water was corrected in the range of 6.5-7 (with NaOH / HCl). Due to the very small section of the bottle

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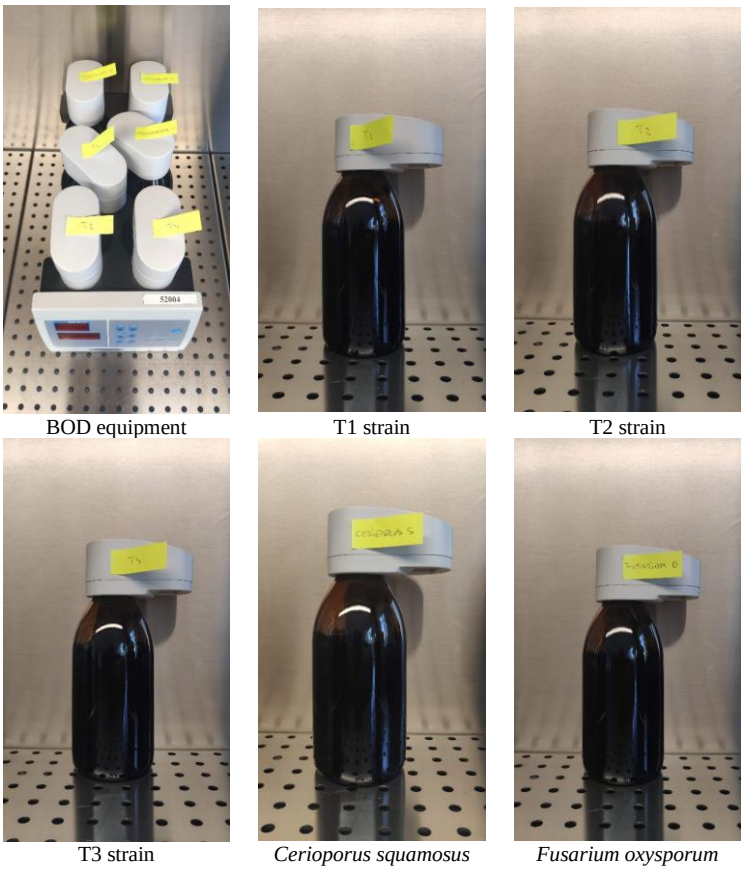
opening, the previously functionalized polymeric supports, with each strain, were sectioned into 2, and a number of ~ 20 carriers were added to each BOD bottle (Figure 2), over which a volume of 300mL of wastewater was poured. The process was carried out for 5 days, with incubation at 20ºC, and continuous stirring, in Lovibond thermoreactor.



BOD equipment | T1 strain | T2 strain

T3 strain | *Cerioporus squamosus* | *Fusarium oxysporum*

Figure 2. BOD bottles with DO counter

Aerobic biodegradation consists in the oxidation of biological organic matter. During this process, the organic matter is transformed by microorganisms into microbial biomass, produced during the biodegradation reaction, assessed according to the following equation:

$$X_0 + S + O_2 \xrightarrow{N,P,MN} X_f + T_p + CO_2 + H_2O \quad (1)$$

where: X_0: initial biomass; S: organic carbon source; O_2: oxygen; N: nitrogen source; P: phosphorous source; MN: mineral nutrients; X_f: final biomass; T_p: products obtained following biodegradation.

For assessment of biochemical oxygen consumption, an incubation period of 5 days was established at a temperature of 20ºC and initial CBO_5 was noted. The biochemical

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oxygen consumption after 5 days was considered the difference obtained between the determination of dissolved oxygen from the initial sample and that after five days from incubation. Biochemical oxygen consumption (CBO_5) is the amount of oxygen, expressed in mg/L, required for the oxidation of organic substances in water by the microorganisms after 5 days of incubation.

COD Method

After the bio-functionalization period, the entire treatment media was evacuated, leaving only the polymeric supports in the reaction vessel. The installation was again loaded with 12L of wastewater. The process was carried out for 14 days, at 28°C, with continuous aeration, in Lovibond thermoreactor. COD values were detected at the beginning of the experiment (T0) and after the end of the experiment (T14), and the result was expressed as a percentage reduction. COD analysis was carried out according to SR ISO 6060, which implies the boiling with reflux for a certain duration, of the water samples mixed with mercury sulphate (III), with a known volume of potassium dichromate, in the presence of a silver catalyst in a strongly acidic environment (sulfuric acid), so that part of the potassium dichromate is reduced by the oxidizable materials present. The excess potassium dichromate was titrated with iron (III) sulphate and ammonium solution. The COD value was calculated from the reduced amount of potassium dichromate. For the boiling stage with reflux, a C.O.D. thermoreactor was used, namely ECO6, Velp Scientifica type, with a temperature set to 200°C.

All reagents used were of known analytical quality:

1. Sulfuric acid (ρ=1,84 g/mL). $c(H_2SO_4)$ = 4 mol/L;
2. Silver sulphate (Ag_2SO_4);
3. Potassium dichromate, reference standard solution. $c(K_2Cr_2O_7)$ = 0.040 mol/L;
4. Iron (II) sulphate and ammonium, titrated solution. $c[(NH_4)_2Fe(SO_4)_2* 6H2_0]$ = 0.12 mol/L;
5. Ferroin (as an indicator solution).

The chemical oxygen consumption (COD) expressed in milligrams oxygen per liter is calculated according to the formula:

$$COD\ (mg/L) = [800c(V_1-V_2)]/V_0 \quad (2)$$

where: c = concentration of the amount of substance of iron (II) sulphate and ammonium solution; V_0 = the volume of the sample to be analyzed, before dilution (if performed), in milliliters; V_1 = volume of iron (II) sulphate and ammonium solution, used for titration of the control sample, in milliliters; V_2 = volume of iron (II) sulphate and ammonium solution, used for titration of the sample to be analyzed, in milliliters; 8000 = molar mass of ½ O_2, in milligrams per liter.

RESULTS AND DISCUSSIONS

A BOD meter was used to measure the initial concentration of dissolved oxygen (mg/L) in each sample container. After five days, the final dissolved oxygen concentration was measured. The concentration of CBO was expressed as difference between initial one and after the incubation, the percentage reduction values of the CBO values for each set of functionalized polymeric supports being highlighted in Figure 3.

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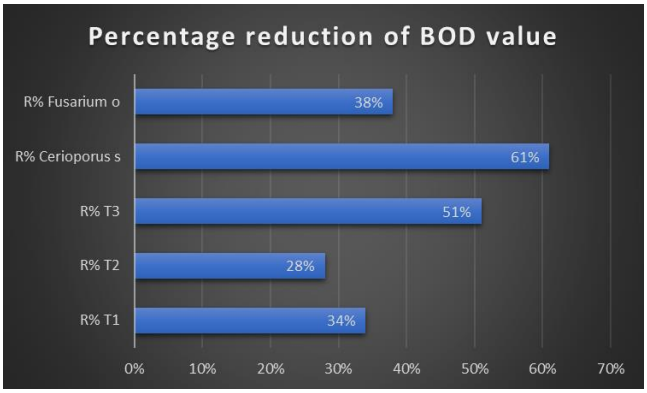

Figure 3. CBO percentage reductions for each strain

The highest reduction rate of CBO value, at 5 days, can be observed on polymeric carriers functionalized with *Cerioporus squamosus* strain (WRF strain - White Rot Fungi), with 61%, and at the opposite pole, the T2 isolate showed the lowest rate of percentage reduction, respectively 28%.

COD analysis is a general indicator of the water quality, measuring the capacity of dissolved oxygen depletion, in the samples contaminated with organic matter (Zhang *et al*., 2017). Specifically, the analysis determines the equivalent amount of oxygen required for chemical oxidation of organic compounds in water. The results highlighted an initial COD value of 61.075mg/L. Following the treatment, in the experimental installation, a reduction of the COD value of 53.45% (32.644mg/L) was observed (Figure 4).

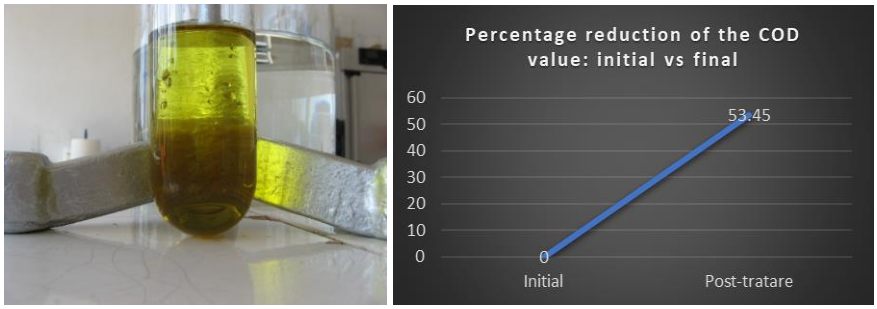

Figure 4. Percentage reduction of the COD value

Following microbial treatment, with bio-augmented HDPE carriers, a satisfactory reduction of the COD value could be observed, also taking into consideration the possibility of a high bacterial load in the wastewater, which can have a real inhibitory effect on fungal populations.

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CONCLUSIONS

Present study aimed the exploitation of novel wastewater treatment technique, consisting of bio-augmentation of HDPE structures with either singular fungal strains or mix of strains (representatives of both Ascomycota and Basidiomycota phyla).

Based on a previous microbial screening, regarding ability to colonize HDPE structures, five microbial strains were selected, representing the phyla Ascomycota and Basidiomycota: own isolates T1, T2 and T3, and two collection strains, respectively *Cerioporus squamosus* and *Fusarium oxysporum*. Experiments were performed to reduce the values of both Chemical Oxygen Consumption (COD) in the experimental installation, on polymeric supports functionalized with the *Cerioporus squamosus* strain. The obtained results showed good rates of reduction of COD values (percentage reduction of 53.45%). At the same time, the installation was tested for the functionalization of 5 batches of polymeric supports, with the five selected strains, and the BOD analysis was performed at 5 days, highlighting rates of reduction of BOD value between 28% (isolated T2) and 61% (*Cerioporus squamosus*). Results obtained show promising applicability of artificial bio-augmented HDPE carriers for treatment of wastewater (Yang *et al*., 2009).

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