PERSPECTIVES FOR BIOPOLYMERS RECOVERED FROM A FULL-SCALE ACTIVATED SLUDGE SYSTEM

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ABSTRACT

Extracellular polymeric substances (EPS) from microbial biomass (biological sludge) from aerobic wastewater treatment processes stand out as an added-value bioproduct with diverse applications. Alginate-like exopolymers (ALE) is a biopolymer contained in EPS and has attracted attention due to its gelling properties. Recovery protocols involve harsh conditions which may injure the enzymatic catalytic properties in EPS. This study presented a modification in the extraction temperature of EPS and evaluated its recovery yield, composition and hydrogel beads formation. Samples from residual activated sludge were obtained at a full-scale activated sludge system. Lower temperature (50ºC) resulted in lower recovery yield (45.67 mg_{EPS}/g_{Sludge}) but similar protein concentration (99.6 mg_{BSA}/g_{Sludge}) when compared to higher temperature (80ºC). Higher glucuronic acid concentration and better hydrogel beads formation were obtained using higher extraction temperatures. The reduction in extraction temperatures may present new perspectives for the recovery of biopolymers while maintaining the structure of biological molecules.

Keywords: Biopolymers. Extracellular polymeric substances. Aerobic sludge. Resource recovery. Activated sludge.

1 INTRODUCTION

Activated sludge (10%), stabilization ponds (37%), and anaerobic reactors (35%) are the most applied wastewater treatment processes in Brazil[1,2]. However, regardless of the process, a common issue in wastewater treatment plants is sludge management since this byproduct needs to be properly disposed of. Activated sludge is an aerobic process that generates huge amounts of residual biomass – biological sludge. Thus, residual sludge could alternatively be explored for resource recovery instead of being disposed of in sanitary landfills.

Adsorption and bioconversion are the main mechanisms of pollutant removal in the activated sludge systems. Both mechanisms are driven by enzymes and biopolymers embedded in the Extracellular Polymeric Substances (EPS) matrix. Alginate-like Exopolymer (ALE) is one of the main functional polymers responsible for the gel formation capacity of EPS[3]. Due to its physico-chemical properties, ALE exhibits potential for various applications, such as impermeable coatings, fire retardants, adsorbent material, encapsulation agent and other[4].

Despite its technological potential, EPS and ALE recovery from full-scale activated sludge systems was not yet well studied. In addition to the ALE, EPS contains enzymes and other biomolecules which can be recovered and reused as a valuable resource[3]. Biomolecules are labile to high temperature and other harsh conditions so, moderate extraction temperatures may be employed to overcome this limitation. So, this work evaluated the impact of reduced temperature in the extraction procedure of EPS and ALE from waste activated sludge.

2 MATERIAL & METHODS

The samples were collected in the activated sludge system of the Lagoa da Conceição Wastewater Treatment Plant (WWTP) of the municipal sanitation company (CASAN), located in Florianópolis, southern Brazil. The mixed liquor was characterized by analyzing the solids according to Standard Methods[5].

The procedure for ALE extraction followed a protocol which contains the sequence for alkaline extraction (Na_2CO_3) at 80ºC and 50°C, centrifugation (2.150g, 25 minutes) and precipitation (HCl, 1M). The yield for ALE extraction was calculated according to the total solids (TS) and volatile solids (VS)[5,6].

The formation of the biosorbent beads from mixtures of ALE and 1% (m/v) sodium alginate solution was studied for three ratios, containing 2.5%, 5% and 10% alginate/volume of ALE. The pellet of ALE previously obtained presented pH enhanced up to 8.5 (0.5M, NaOH), mixed with alginate and dripped in a 12% $CaCl_2$ solution, to make the hydrogel beads.

To determinate the protein concentration (PN) a modified Lowry method[7], considering the interference of humic substances. The polysaccharides (PS) were determined using a modification of the classic anthrone method[8], which allows quantifying the neutral and uronic sugar fractions in a single experiment. The samples were prepared in triplicate and the results were expressed in terms of total volatile solids concentration.

3 RESULTS & DISCUSSION

According to Figure 1, the EPS extraction yields using 50°C and 80°C were 45.67 mg_{EPS}/g_{Sludge} and 64.85 mg_{EPS}/g_{Sludge}, respectively. Besides higher extraction yield, higher temperature (80ºC) also favored the polysaccharides and protein concentration (Figure 2). The glucuronic acid is the monomer responsible for the ALE hydrogel properties and its concentration increased 1.5 times when the temperature was higher. According to the hydrogel test shown in Figure 3, the EPS beads extracted at 80ºC are tight and structurally more stable when compared to those extracted at 50ºC, corroborating the influence of glucuronic acid concentration.

The protein's concentration was slightly affected by the temperature, in terms of concentration. However, their functional properties such as the catalytic capacity were not evaluated. Enzymatic analysis would answer if the temperature reduction for this extraction method is a strategy to maintain the biological activity of proteins embedded in the EPS matrix.

The ability to form hydrogel in the presence of cationic ions was proven, through the formation of beads when dropped in calcium chloride solution. The beads formation indicates that ALE is part of the EPS, whereas the temperature extraction influenced the biopolymer composition and its physic-chemical properties.

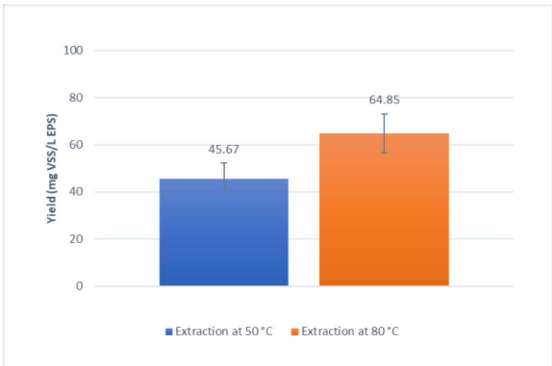

Figure 1 EPS extraction yield at 50 and 80ºC.

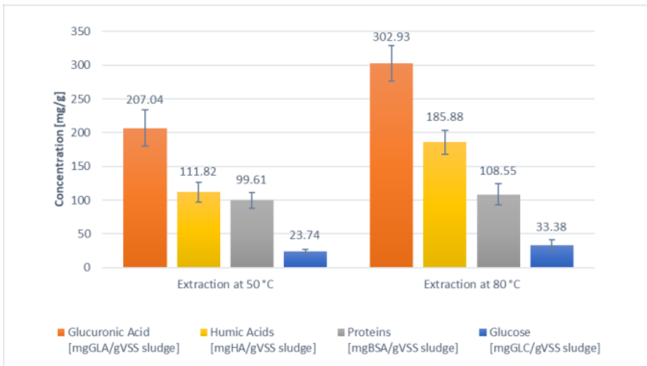

Figure 2 Characterization of EPS extracted at 50 and 80ºC.

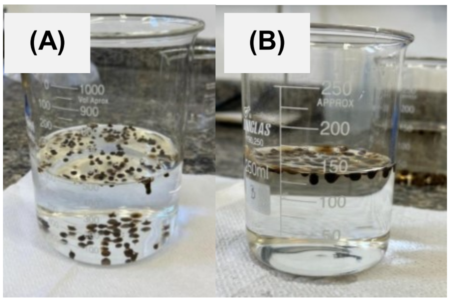

Figure 3 EPS Hydrogel beads extracted at 50 °C (A) and 80°C (B).

4 CONCLUSION

It is worth noting that the recovery of EPS and ALE holds greater application potential, as activated sludge systems are widely used in wastewater treatment plants in Brazil. The studied full-scale activated sludge system is a source of residual biomass with the potential for EPS and ALE recovery.

The temperature reduction proposed in this study slightly affected the EPS extraction yield. This protocol modification may overcome the limitation of using high temperatures when the biological activity of proteins such as enzymes is the added-value product to be recovered. Future studies dealing with the activity of key enzymes in the EPS matrix and the effect of the extraction procedures may reveal their potential to be recovered and used.

The recovery of EPS with a focus on maintaining enzyme activity will provide support for the formulation of biotechnological products for environmental applications, which require the adsorption of pollutants and their bioconversion, such as bioflocculants or a biocatalysts.

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ACKNOWLEDGEMENTS

We would like to thank the Companhia Catarinense de Água e Saneamento (CASAN) for supporting activated sludge samples for this study, the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the financial support through the Universal Project nº: 403786/2023-1, as well as the Federal University of Santa Catarina for the undergraduate students scholarships.