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Biopolymers recovery from activated sludge and its use as phosphorus biosorbent from piggery wastewater

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Highlights:

- Phosphorus adsorption using biopolymers recovered from activated sludge
- 75% of phosphorus removal from piggery wastewater

Keywords: Biopolymer; Phosphorus; Adsorption

INTRODUCTION

The mineral exploitation of phosphorus for its use as a fertilizer contributes to the scarcity of its reserves which are estimated to be exhausted in the next century. In this scenario, the recovery of phosphorus from effluents becomes an alternative aligned with the concept of the circular economy (EGLE et al., 2016).

Among the main effluents with high phosphorus content, piggery wastewater stands out. The raw effluent from pig farming can contain phosphorus levels of around 2700 mg/L (CHEN et al., 2020).

The adsorption process has been used as a promising technique to remove and recover nutrients from effluents, such as phosphorus (WANG et al., 2018). The adsorbed phosphorus could be used in agriculture, promoting reduction in the need for mineral fertilizers (EGLE et al., 2016).

The biological sludge from wastewater treatment processes is a source of biopolymers, such as alginate-like exopolymers (ALE) that can be extracted and reused, which emphasize the transformation of residual waste into value-added products of economic interest. In this context, this work evaluates the biopolymers recovery from Activated Sludge (AS) and it´s use to adsorb phosphorus from piggery wastewater.

METHODOLOGY

AS samples were collected from the Insular Wastewater Treatment Plant (WWTP) of the municipal sanitation company (CASAN), located in Florianópolis, Brazil.

The procedure for ALE extraction and recovery followed a protocol which contains a sequence of alkaline extraction (Na_2CO_3) at 80ºC, centrifugation (2.150g, 25 minutes) and precipitation (HCl, 1M).

The biosorbent beads were formed by mixing ALE and 1% (m/v) and sodium alginate at 2.5%. The mixture was dripped in a 12% $CaCl_2$ solution, to make the hydrogel beads.

Piggery wastewater was sampled from a biodigester and diluted 25 times to follow previous experimental concentrations used for synthetic phosphorus solution adsorption (CABRAL et al., 2024). Total phosphorus (TP), chemical oxygen demand (COD) and ammonium nitrogen ($N\text{-}NH_4^+$) were analyzed accordingly (APHA, 2017).The adsorption experiments were performed on 250 mL-Erlenmeyer flasks with 100 mL of diluted piggery effluent and 150 g/L (wet weight) of ALE-alginate biosorbent. The flasks were shaken in a thermostatic bath at 133 rpm, 25°C for 60 minutes. Samples were taken at 0, 5, 15, 30 and 60 minutes, centrifuged and analyzed for nutrients and COD.

RESULTS AND CONCLUSIONS

The average yield of ALE recovery from AS (187±13 $mgVS_{ALE}/gVS_{sludge}$) was consistent with other authors (CHEN et al 2022). AS holds greater application potential, since these systems are widely used in wastewater treatment plants in Brazil.

The piggery effluent presented TP, COD and $N\text{-}NH_4^+$ concentration of 3250 ± 445 mg/L, 24620 ± 3970 mg/L e 7380 ± 650 mg/L, respectively. The COD and nutrients concentration after dilution were reduced to 130, 985 and 295 mg/L, respectively.

TP removal efficiency of 79% was achieved after 60 minutes of adsorption but in the first 5 minutes the TP concentration was reduced from 130 to 25 mg/L. The COD was reduced from 985 to 711 mg/L after the first 15 minutes, followed by gradual increase to 901 mg/L in 60 minutes. The $N\text{-}NH_4^+$ followed the same pattern, reducing from 295 to 226 mg/L after 15 minutes and increase to 266 mg/L in 60 minutes. This may be related to the beads disintegration after 15 minutes due to the shaking conditions of the thermostatic bath, releasing carbonaceous and nitrogenous matter to the aqueous solution. However, there was no increase in the compared to the initial concentrations. Therefore, AS holds potential for biopolymers recovery and subsequent use as a phosphorus adsorbent from piggery effluents to be further used as a source of this nutrient and other compounds.

FIGURES and TABLES

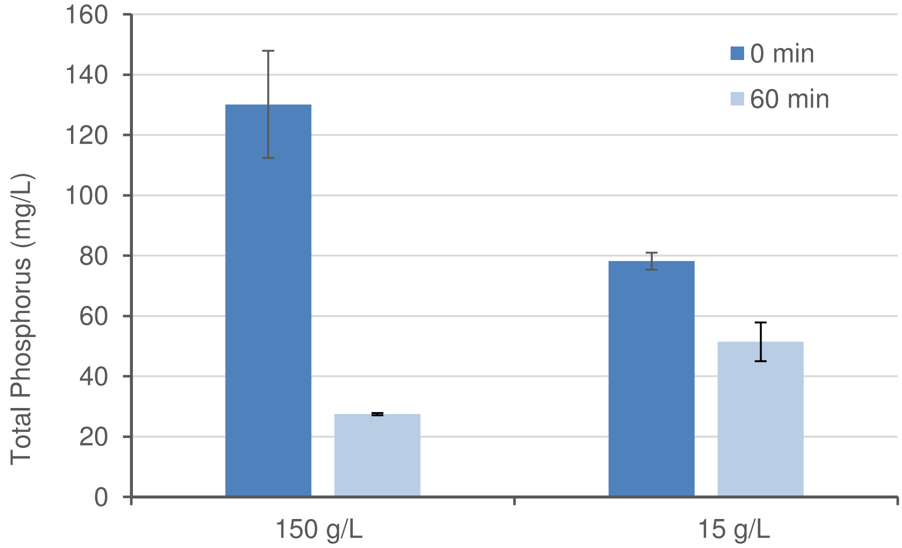

Figure 1 - TP concentration before and after adsorption using 150 and 15 g/L of adsorbent.

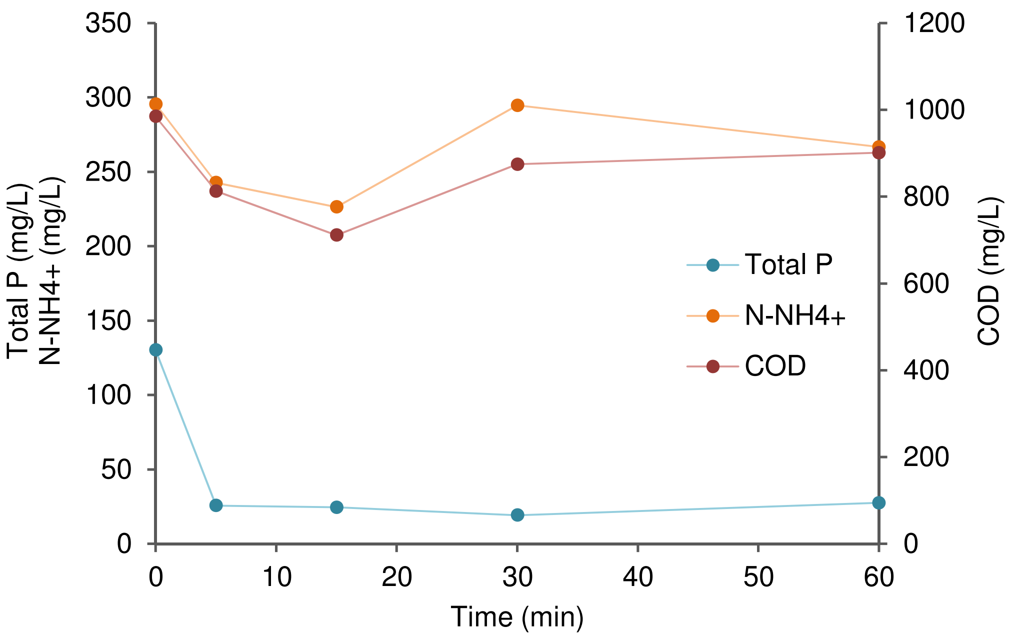

Figure 2 - TP, $N\text{-}NH_4^+$ and COD concentration during adsorption of piggery effluents using 150g/L of adsorbent.

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