IMPACT OF POLY-ALUMINIUM CHLORIDE OVER SPECIFIC METHANOGENIC ACTIVITY

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ABSTRACT

Upflow Anaerobic Sludge Blanket Reactor (UASB) followed by Activated Sludge (AS) is a common arrangement for Wastewater Treatment Plants. Poly-aluminium chloride (PAC) can be applied in the AS reactor to remove phosphorus (P) through co-precipitation. However, the P-rich excess aerobic sludge sent to UASB for digestion could impact the specific methanogenic activity (SMA).The objective of this work was to evaluate the SMA of the anaerobic sludge from a UASB reactor, and the impact of PAC over the biogas production. The tests were performed in 200-mL reactors and the biogas measured through eudiometer tubes. The biomethane was quantified with a portable gas analyzer. PAC did not generate inhibition of methanogenic activity at concentrations up to 0.65 g/L. The concentration of 26 g/L of PAC, on the other hand, resulted in the complete inhibition of biogas production. PAC inhibits SMA only under high concentrations.

Keywords: Specific Methanogenic Activity; Anaerobic Sludge; Upflow Anaerobic Sludge Blanket Reactor (UASB); Biogas; Anaerobic digestion.

1 INTRODUCTION

The UASB reactor is a technology that has been widely used in domestic wastewater treatment, making use of the principles of anaerobic digestion, where around 70 to 90% of biodegradable organic matter is converted into biogas, especially carbon dioxide and methane. Therefore, the removal of organic substrates from effluent is highly related to methane production (Aquino et al., 2007)[1]. The evaluation of the SMA of anaerobic sludge is important to monitoring the efficiency of the methanogenic bacteria in the reactor, which act in the final phase of anaerobic degradation, thus characterizing itself as an operational control tool (Aquino et al, 2007)[1].

UASB reactor followed by AS reactor is an arrangement commonly found in WWTP in Brazil, taking advantage of anaerobic process efficiency in removing organic matter without energy input for aeration, together with aerobic efficiency in removing nutrients. Also, the excess aerobic biomass is sent to the UASB reactor for digestion, reducing sludge volume and reactivity.

The chemical precipitation in the aerobic reactors is a strategy to improve phosphorus removal. Phosphorus molecules bind to the coagulating agents, like PAC, resulting in the precipitation of the nutrient for subsequent removal when the sludge is removed, or sent to the UASB reactor.

Therefore, the present work proposed the evaluation of the SMA of anaerobic sludge from a UASB reactor, located in Florianópolis/SC, with and without PAC addition, aiming the evaluation of the inhibitory effect of this coagulating agent.

2 MATERIAL & METHODS

The volumetric method with eudiometer tubes was used to measure the volume of biogas produced in the reaction flasks. The reactor flasks contained 2.5gVSS/L of anaerobic sludge, sodium acetate at 2g/L and a nutrient solution of macro and micronutrients, according to (Chernicharo et al, 2007)[2].

The SMA tests with different dosages of PAC (0.108, 0.650 and 26g/L) were carried out according to the PAC concentrations added to the WWTP. The SMA test was monitored daily, with controlled temperature at 30°C, and the pH was monitored in the range of 6.7 to 7.7. The biogas composition was evaluated by the Biogas 5000 gas analyzer (Landtec). The VSS and the COD were performed according to (APHA, 2017)[3].

3 RESULTS & DISCUSSION

The SMA was conducted by adding different concentrations of PAC to the inoculum, whereas the accumulated biogas volume is shown in Figure 1.

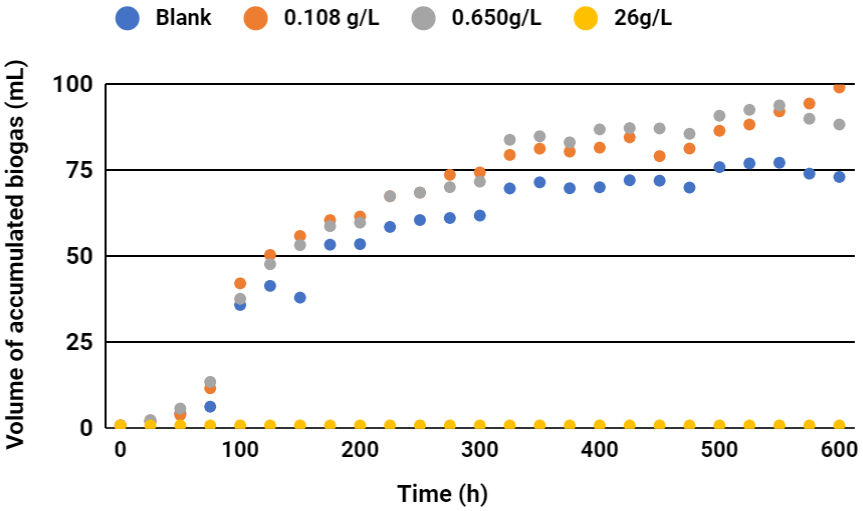

Figure 1 Evaluation of AME inhibition through PAC

All the tested reactors showed a stationary phase up to 42h and no biogas production was registered. After 42h, the blank reactor, 0.108g/L, and 0.65g/L PAC reactors presented a constant growth followed by a stationary phase at 353h. In contrast, no biogas production was observed in the reactor with 26g/L of PAC. Table 1 summarizes the results of PAC inhibition over SMA tests.

Table 1 Summary of results from PAC inhibtion over SMA

PAC (g/L)	Al_2O_3* (g/L)	Biogas Volume (mL)	Methane Volume (mL)	SMA (gDQOCH$_4$/ gSSV.d)
0	-	77.07	15.49	7
108	11.1	99.13	20.52	8
650	66.8	93.92	19.54	8
26000	2670.2	-	-	0

* Al_2O_3 content in PAC (10.27%), according to the supplier technical specification.

Despite the slight difference, the reactor with the best performance in terms of biogas production was the one with 0.108g/L, followed by 0.65g/L, and then the one without PAC addition. These results demonstrate that low concentrations of PAC did not inhibit the methanogenic activity. However, in excessive concentrations, PAC has the ability to inhibit microbial activity.

The reactor test without PAC (0 mg/L) showed SMA results below that recommended by (Chernicharo, 2007)[2] for UASB reactors fed with domestic wastewater (0.3 – 0.4 gDQOCH$_4$/gSSV.d). This result suggests that the anaerobic sludge used in this study is already affected by PAC that is continuously added to the AS reactor at 0.108g/L and may undergo to the UASB reactor in the WWTP. PAC inhibition has not yet reached its critical concentration, but this does not mean that it cannot occur over time.

The low levels of methane in the biogas composition, combined with the low biogas generation in SMA tests, prove a low microbial activity of the inoculum analyzed. The results found reflect a difficulty in degrading organic matter, which may be affected by different factors (Table 2).

The methane concentration in all the tested reactors were still lower than expected in the literature (between 60% and 85%). However, CH_4 levels are higher than CO_2 levels, demonstrating a more balanced anaerobic degradation process. At PAC concentration of 26g/L, the methane percentage was close to zero. This fact, combined with the absence of biogas generation in this reactor flask, confirms the inhibition of methanogenic activity at these concentrations.

Table 2 Biogas composition in the tested reactors with and without PAC

	Blank	0.108g/L	0.650g/L	26g/L
CH_4 (%)	20.1	20.7	20.8	0.5
CO_2 (%)	7.3	7.5	6.8	5
O_2 (%)	1.8	0.9	1.7	1.8
H_2S (ppm)	22	41	31	14
Others	70.7	70.9	70.7	92.8

4 CONCLUSION

The SMA of anaerobic sludge collected from UASB reactors were evaluated, and the possible inhibition caused by PAC addition as a co-precipitation agent. PAC at concentrations up to 0.65 g/L did not affect the SMA and the biogas composition, although the sludge without PAC also showed low SMA. However, the concentration of 26 g/L resulted in complete inhibition of microbial activity. This study revealed that the current applied PAC concentration in the WWTP does not affect the SMA, but possible PAC accumulation in the reactors should be evaluated in the future.

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