INSIGHTS OF THE UASB REACTOR COUPLED WITH INNOVATIVE PROCESSES FOR THE TREATMENT OF WASTEWATER

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ABSTRACT

The article discusses the growing demand for water treatment due to rapid population growth and disorganized urbanization, emphasizing the need for adequate treatment of generated effluents. In the Brazilian context, less than half of the urban sewage generated is treated, which is a common reality in many developing countries. The article highlights the UASB (Upflow Anaerobic Sludge Blanket Reactor) as a popular option for treating industrial effluents due to its effectiveness. An approach was brought about UASB and the different systems that can be incorporated in order to seek better results and greater efficiency. During the discussion, examples were brought of UASB coupled to an ABR for the treatment of vinasse, an MFC system with the objective of removing nitrogen from the environment in which it is located, and other examples that the use of a system coupled to UASB brings better results and a more expected efficiency when we talk about water treatment..

Keywords: Anaerobic system. Effluent treatment. Coupled systems.

1. INTRODUCTION

The accelerated population growth in recent decades, combined with the process of disorganized urbanization, has resulted in increased demand for water and, consequently, greater effluent generation[1]. These effluents, rich in organic matter and nutrients, alter the characteristics of the receiving body and compromise its multiple uses when discharged without proper treatment.

Among the various anaerobic systems available in the literature, the UASB reactor is one of the most popular and has been applied to the treatment of numerous types ofwastewater. The UASB reactor is fed from the bottom, with upward flow, so that the raw effluent comes into contact with the biomass present in the reactor, which resides in the sludge blanket zone. As a result of anaerobic activity, gases are generated, and the bubbles formed follow the effluent flow. The top part of the reactor features a three-phase separator, which functions to separate the liquid, solid, and gas phases. The gas is directed to the top for collection, the liquid to the distribution channels, while the solid fraction collides with a physical barrier and returns to the sludge blanket[2].

Biological treatment using an anaerobic system such as UASB followed by an aerobic system has already been widely used and recommended[3]. The UASB can operate efficiently with high organic loads and variations over time, amid an accelerated hydraulic detention time[4]. However, the effluent still has concentrations above the legislation or toxicity. Thus, complementary or integrated physical-chemical and/or biological processes become an attractive solution.

Thus, this review sought to provide insights into the possibilities of integrating processes into the UASB as a way of obtaining an efficient wastewater treatment system.

2. MATERIAL & METHODS

The literature review focused on wastewater treatment using a UASBreactor acting in synergy with other treatment systems. To this end, the following Boolean operators were used: "UASB" OR "anaerobic reactor" AND "wastewater" OR "effluent" AND "coupled" OR "integrated" OR "combined" in the Web of Science and Scopus databases. Thousands of documents were reported, however, after selecting scientific articles written only in English and that fit the scope, some outstanding papers were selected that presented significant innovation in terms of comibining physcochemical and/or biological processes with the UASB.

3. RESULTS & DISCUSSION

The search for papers involving the combination of UASB with other treatment processes resulted in hundreds of documents, but five articles were selected for discussion. Table 1 shows the systems and main highlights found by the authors.

Table 1 Main highlights of UASB systems combined with innovative processes applied to wastewater treatment

System	Wastewater type	Highlights	Ref.
UASB with anaerobic baffled followed by an activated slude	Wastewater from the ethanol industry (vinasse)	COD removal of 99.6% and production of approximately 72% methane	5
UASB with microbial fuel cell	Nitrogen removal from the environment through the use of microbial fuel cell electrodes and the presence of an anaerobic sludge blanket	The presence of the anode as an electron acceptor increased the total nitrogen removal under anammox conditions in the UASB-MFC with high voltage production	6
Complete Ammonium and Nitrate removal via Denitritation-Anammox over Nitrite within a UASB	Nitrogen removal from municipal wastewater using the CANDAN process in a UASB reactor	A nitrogen removal rate of approximately 84% was obtained. Inorganic nitrogen compounds, including ammonium, nitrate and nitrate, can be eliminated. .	7
UASB coupled with microalgae photobioreactors	Treatment of slaughterhouse effluents using a two-phase anaerobic reactor coupled to microalgae photobioreactors	Integrated microalgae system achieved organic matter and nutrient removal of 90 to 99.31%. Conversion of slaughterhouse effluents into value-added products such as biogas biodiesel and clean water.	8
UASB in serie with artificial wetland	Treatment of slaughterhouse effluents through an UASB-Wetland, proposes the removal of organic matter through anaerobic-aerobic microbiological processes	UASB-Wetland, presented 88% COD removal and 84% BOD removal. The system required low implementation and operation costs as it was based only on biological processes.	9

According to Mazaheri et al.[5] the UASB reactor was used, and a simple, low-cost combined system was designed for vinasse treatment. Wastewaters from the ethanol industry contain high concentrations of organic matter, toxic substances, and hard biodegradable compounds. The authors used an UASB and an anaerobic baffled reactor (ABR) in his research. Synthetic vinasse was used in this project with an organic loading rate. In the end, it was observed that the UASB-ABR combination proved effective for vinasse treatment, as the system showed a COD removal rate of 99.6% and methane production of approximately 72%.

Proposed by Iqbal et al.[6] the high nitrogen content in wastewater is an environmental concern, especially in developing countries, as it has a dangerous impact on human well-being and water resources. The use of electrodes in the microbial fuel cell with an upflow anaerobic sludge blanket (UASB) improves nitrogen removal from the environment. Experimental configurations were used in the treatment process for ammonium removal with and without electrodes. Ultimately, the presence of the electrode oxidized the nitrogen and resulted in better removal efficiency than without the electrode; in the UASB, nitration and nitration were higher than in the UASB-MFC. It is concluded that the presence of the anode as an electron acceptor increased total nitrogen removal under anammox conditions in UASB-MFC with high voltage production. Lower concentrations of nitrate, nitrite, and total inorganic nitrogen were found in the UASB-MFC effluent.

In line with Cao et al.[7] proposed biological nitrogen removal from nitrate sewage through the new CANDAN process in a continuous flow UASB reactor with municipal wastewater, this technology presented a promising low-carbon technology for wastewater treatment and has been widely studied in sequential batch reactors (SBR). This study revealed a very consistent result, with approximately 84% of the nitrogen removed from these wastewater. For this purpose, the CANDAN process (complete removal of ammonia and nitrate via denitrification) can eliminate inorganic nitrogen compounds, including ammonium, nitrite, and nitrate, allowing all types of nitrogen-containing wastewater to be effectively removed.

Tsegaye et al.[8] evaluated the performance of a two-phase anaerobic reactor coupled to microalgae photobioreactors for the treatment of effluent from slaughterhouses in Ethiopia. This system proposed the absorption of wastewater from slaughterhouses, thus producing biogas in an anaerobic digestion unit by removing most of the organic matter and removing most of the nutrients and residual organic matter in a microalgae photobioreactor. The final result of this study demonstrated that this system integrated with microalgae treatment achieved the highest removal efficiencies, ranging from 90 to 99.31% for organic matter and nutrients, including BOD, SCOD and TCOD effluent, NH4+-N, NO3-, PO4-3, which were below the effluent discharge limit. Therefore, the established integrated biological treatment system composed of AD microalgae photobioreactor showed promising result in converting slaughterhouse industry effluents into value-added products such as biogas, biodiesel and clean water for use by nearby industries and communities.

Concluding with Montero et al.[9], the author presented a process for treating slaughterhouse effluents, through a serial system, which includes an anaerobic Upflow reactor and Artificial Wetland that proposes the removal of organic matter through anaerobic-aerobic microbiological processes, in accordance with a conversion of organic matter from hydraulic processes and phytoremediation and bioremediation. The removal efficiencies in the evaluated System were in accordance with the standards previously established by the region's regulations. This System (UASB+Wetland) achieved acceptable removal efficiency levels, such as 88% COD removal and 84% BOD removal, based on only biological processes. The System required low implementation and operation costs and proved to be sustainable and efficient, since the combined System achieved SWW treatment not only via biological action, but also via sedimentation that occurs in the Wetland System, making it a viable tool for SWW treatment.

4. CONCLUSION

Based on these results, the efficiency of UASB to treat different types of wastewater was observed. The results of the study suggest that the UASB-ABR-AS system is an effective method to treat vinasse, a type of toxic industrial effluent. It is concluded that the presence of anode as an electron acceptor increased the total nitrogen removal under anammox condition in UASB-MFC with high voltage production. Lower concentrations of nitrate, nitrite and total inorganic nitrogen were found in UASB-MFC effluent, suggesting higher conversion of ammonium to nitrogen gas. The CANDAN process can be applied for biological removal of N from nitrate sewage with real municipal wastewater as a co-substrate conducted in a continuous flow UASB reactor. The two-phase anaerobic reactor coupled with microalgae photobioreactors for slaughterhouse effluent treatment has proven effective in integrated biological treatment, bringing promising results in the conversion of slaughterhouse effluents into products for use by companies, such as biodiesel and biogas, and also in the production of clean water. The last process brings an anaerobic Upflow and Artificial Wetland reactor, which proposed the removal of organic matter from the slaughterhouse industry, through anaerobic-aerobic microbiological processes. This process required low costs, was sustainable and efficient, the results of COD and BOD removal were shown to be effective, making the system viable for the treatment of SWW.

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