Advanced Treatment of Wastewater from Food Waste Disposer in Modified Ludzack-Ettinger Type Membrane Bioreactor

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Abstract

This paper proposes a modified Ludzack-Ettinger (MLE) type membrane bioreactor (MBR) as a method of treatment for wastewater from food waste disposer. Micro-membrane filtration allows for an extremely low concentration of suspended solids in the effluent. The effluent of the reactor in question is characterized by a relatively high level of non-biodegradable organics, containing a substantial amount of soluble microbial products and biomass. Results obtained in this paper by measurement of membrane fouling are consistent with biomass concentration in the reactor, as opposed to chemical oxygen demand (COD). The MLE process is shown to be effective for the treatment of wastewater with a high COD/N ratio of 20, resulting in a markedly high total nitrogen removal efficiency. Denitrification could be improved at a higher internal recycle ratio. Despite the low concentration of influent phosphorus, the phosphorus concentration of the outflow is seen to be relatively high. This is because outflow phosphorous concentration is related to COD consumption, and the process operates at a long solids retention time.

Keywords: Disposer, Food waste, Membrane bioreactor, Modified Ludzack-Ettinger process, Wastewater treatment

1. Introduction

In order to encourage the beneficial reuse of animal feed, fertilizers and other organic substances, disposal of organic waste in landfills is forbidden under Korean law. This recycling policy for food waste, in tandem with concerns about environmental and technical problems, has also restricted the use of food waste disposers. One particular concern is the possibility for increased loadings on existing wastewater treatment facilities, since disposers disintegrate kitchen waste, then transfer it to sewers for transportation. However, demand for efficient transportation of food waste has risen, due to recent problems with alternative technologies. Convenience is not the only concern when it comes to disposer technology; other, more drastic effects must also be considered [1]. In Korea, where people separate food waste into a recycling box by themselves, the application of food waste disposers seems to be a particularly attractive option, since the odors produced by recycling boxes and unpleasant aesthetics near collection areas are both targets of public grievance.

Disposer systems are considered for kitchen waste treatment on the assumption that additional treatment of wastewater from the disposer is introduced, to mitigate the adverse effect on sewerage. This technology, of disposers combined with on-site wastewater treatment systems, has been studied in Japan [2]. However, it is very different from disposer systems widely applied in USA, where disposer wastewater is transported to public wastewater treatment plants. Many on-site wastewater treatment processes have been developed, and have become popular in Japan; most of these systems are household-sized units, with a capacity of 1-2 m³/day [3]. In order to remove both nitrogenous and carbonaceous pollutants, wastewater treatment generally makes use of biological nutrient removal (BNR) processes, designed to include anaerobic, anoxic, and aerobic conditions. Pre-denitrification processes, such as the modified Ludzack-Ettinger (MLE) process, are particularly important for kitchen wastewater containing a high ratio of chemical oxygen demand (COD) to nitrogen. Successful results have also been achieved through application of advanced processes, including nutrient removal in the disposer system [2, 3]. However, settling problems in secondary clarifiers often occur when using the conventional process to treat high strength wastewater, due to the bulking nature of such wastewater [4, 5]. The membrane bioreactor (MBR) process is a
biological treatment process with enhanced solid-liquid separation, by the use of a membrane in the conventional activated sludge process [6]. In MBR, a longer solids retention time (SRT) independent of hydraulic retention times (HRT) is possible, and results in a high biomass concentration and flexibility in operation [7, 8]. These advantages are also desirable for treatment of high strength wastewater, such as that produced by food waste disposers [4]. Recently, MLE coupled with MBR has been used for treating many kinds of wastewater [5]. However, there are few reports that show simultaneous removal of organic materials and nutrients from disposer wastewater using MLE-type MBR.

This paper suggests an MLE-type MBR process as a treatment system for disposer wastewater. The purpose of this study is to investigate the biological treatability of organic materials and nutrients in disposer wastewater, as well as the operational stability of the suggested process.

2. Materials and Methods

2.1. Disposer Wastewater Characterization

The composition of the disposer wastewater is monitored from a pilot facility in Changwon, Korea [9]. In order to reduce fluctuations in the influent, disposer wastewater is comprised of previously suggested standard food waste [2, 10]. Food waste used in the present study has the following composition (wet weight in 35 L of tap water): carrot, 45 g; cabbage, 45 g; banana skin, 25 g; apple, 25 g; grape skin, 25 g; cooked chicken, 20 g; fish, 25 g; egg shells, 5 g; rice, 25 g; tea leaves, 10 g; bean flour, 24 g; corn steep liquor, 30 mL. Food waste is ground down, and stored at 4°C in a refrigerator before use. This results in a composition of disposer wastewater as shown in Table 1. Biochemical oxygen demand (BOD), suspended solids (SS), COD, total nitrogen (TN), and total phosphorous (TP) contents of the samples are measured according to standard methods [11].

2.2. Experimental Set-up

The laboratory scale MLE-type MBR process makes use of a 4 L anoxic tank and 8 L aerobic tank. The membrane module is submerged in the aerobic tank, as shown in Fig. 1. A hollow fiber membrane (KMS Co., Ltd., Yongin, Korea) is used, with a nominal pore size of 0.4 μm, and total membrane area of 0.2 m². The reactor is fed with disposer wastewater, and the effluent is directly drawn from the membrane module via a suction pump. The MBR process operates at a constant permeate flux mode, except when sampling the activated sludge for analysis and excess sludge wasting.

Both systems, MBR1 and MBR2 are operated in parallel. Effluents (membrane permeate) are intermittently withdrawn at sequential intervals of 10 min suction and 2 min idle, in order to diminish membrane fouling. A diffuser is used to provide continuous aeration at the bottom of the tank. The permeate flux is set at 7.5 and 15 L/m²/hr, and the corresponding HRT of the process is 18 and 36 hr, longer than normal for MLE plant sewage treatment [12]. Peristaltic pumps are used to maintain water flows, including influent wastewater, internal recycle (IR) ratio, and

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<th>Table 1. Composition of disposer wastewater</th>
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<td>BOD (mg/L)</td>
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<td>Monitored actual data</td>
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BOD: biochemical oxygen demand, SS: suspended solids, COD: chemical oxygen demand, TN: total nitrogen, TP: total phosphorous.