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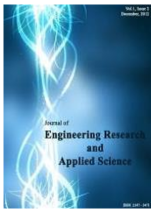

Treatment of domestıc wastewater by membrane bıoreactor system (MBR)

K.Ozan[1], C.Acikgoz[2,a]

[1] Bilecik Seyh Edebali University, Pazaryeri Vocational High School, Bilecik, Turkey.
Bilecik Seyh Edebali University, Chemical and Process Engineering, Bilecik, Turkey.

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Abstract

The reuse of waste water after treatment has become widespread all over the world. By treating the waste water, the fresh water supplies can be protected by shortening the water cycle in the nature, and the need for water can be compensated. The aim of this study was to state performance of the membrane bioreactor (MBR) system for domestic wastewater. In this experimental studies, synthetic wastewater was prepared to represented wastewater with partial urine separation and kitchen wastewater was mixed to from the required wastewater stream. Samples were taken for analysis from wastewater tank, aeration tank and permeate outlet. COD, phosphate and nitrogen concentration value were analyzed daily in influent as well as effluent to assess the removal efficiency. As result of experimental studies, the removal efficiency of COD, phosphate and nitrogen was determined as %90; %88 and %91, respectively.

Keywords: MBR; domestic wastewater treatment; COD; active sludge

1. Introduction

Domestic wastewater is the water that has been used by a community and which contains all the materials added to the water during its use. Untreated wastewater causes major damage to the environment and to human health. Any water that has been used in the home, except water from toilets, is called grey water. Dish, shower, sink, and laundry water comprise 50-80% of residential "waste" water. This may be reused for other purposes, especially landscape irrigation. Grey water can replace fresh water in many instances, saving money and increasing the effective water supply in regions where irrigation is needed. Many people have investigated the various waste water treatment methods extensively on the international and national levels and many researchers tried to reduce the cost for recycling of the water. MBR technology has proven quite effective in removing organic and inorganic contaminants as well as microorganisms from wastewaters and has gained increasing popularity due to stringent environmental regulations and growing water reuse initiatives in recent years. MBR systems essentially consist of combination of membrane units responsible for physical separation, and biological reactor systems responsible for biodegradation of waste compounds. Membrane Bioreactors are a combination of activated sludge system and membrane technology. Membrane bioreactors are making rapid progress in both research and commercial applications [1-3]. More research on water reclamation using MBR can be found form the literature. MBRs are considered an ideal wastewater treatment technology in areas with landfills because of their compact size and the ability to obtain reusable effluent quality [4-15].

Rosenberger and et. al. were investigated the treatment of domestic wastewater by submerged MBR system. During the experiments, the concentration of mixed liquid suspended solids ranged from 18 to 20 g / L in the reactor. At the end of the treatment 95% COD and 82% total nitrogen depletion were recorded [16].

Naghizadeh et.al. were studied that the performance of hollow fiber micro filtration membranes immersed in a bioreactor for removal of chemical oxygen demand (COD), total suspended solids (TSS) and turbidity from municipal wastewater. A satisfactory effluent quality was obtained at all HRTs and the COD removal efficiencies under all operating conditions were >96%. COD removal in the bioreactor decreased slightly with decreasing HRT [17].

[a] Corresponding author;
Phone: +90-228-214-1233, Email: caglayan.acikgoz@bilecik.edu.tr

Cote et al. discovered that a submerged membrane was placed in an aeration tank for municipal waste water treatment with an anoxic–aerobic process, total Kjeldahl nitrogen (TKN) removal efficiencies were greater than 69 and 94% at mixed liquor suspended solids (MLSS) concentrations of 15,000 and 25,000 mg/L, respectively [18].

MBR technology and its application in domestic and industrial wastewater treatment systems has recently attracted closer attention because of demands to deliver effluents of higher standards and with more reliable quality [17]. In this study, the reuse areas of waste water have been investigated by treating the synthetic waste water with domestic characteristics via a lab/pilot scale membrane bioreactor system (MBR). The daily domestic wastewater and kitchen waste generation were estimated in a real household. The generation of domestic wastewater from four person household as 728 L/d (TUİK, 2015) and 7.2 % of the total amount (50L/d) was used for the experimental studies.

2. Materials and Methods

The MBR system had a working volume of 170 L and was equipped with a coarse and fine air bubble creation mechanism for membrane and biological aeration, respectively. Ultrafiltration membrane module, which had an area of 1.5 m2, was consists of 6 flat-sheet membrane (PVDF + PET) with the pore size of 0.08–0.3 μm and vertically placed in the aeration tank. The system was managed by an LCD display on the control panel. The process controls encompassed PH, dissolved oxygen (DO) and temperature, which were automatically controlled at predetermined levels. The pH was monitored and controlled using a PH process controller (Mettler Toledo 405-50 SC-pH 7, Switzerland) which activated pumps for the addition of 1N HCL or 1 N NaOH. The DO level was adjusted using a dissolved Oxygen Module (Mettler Toledo Inpro6000, Switzerland) to control the air flow rate. Figure 1 is a schematic diagram of the lab/pilot scale MBR system[19]. The temperature of the aeration tank was controlled at 20 ± 1 °C, the pH value and the concentration of dissolved oxygen (DO) was kept respectively, in the range of (7,0-8,0) and 3-4 mg/L in the aeration tank.

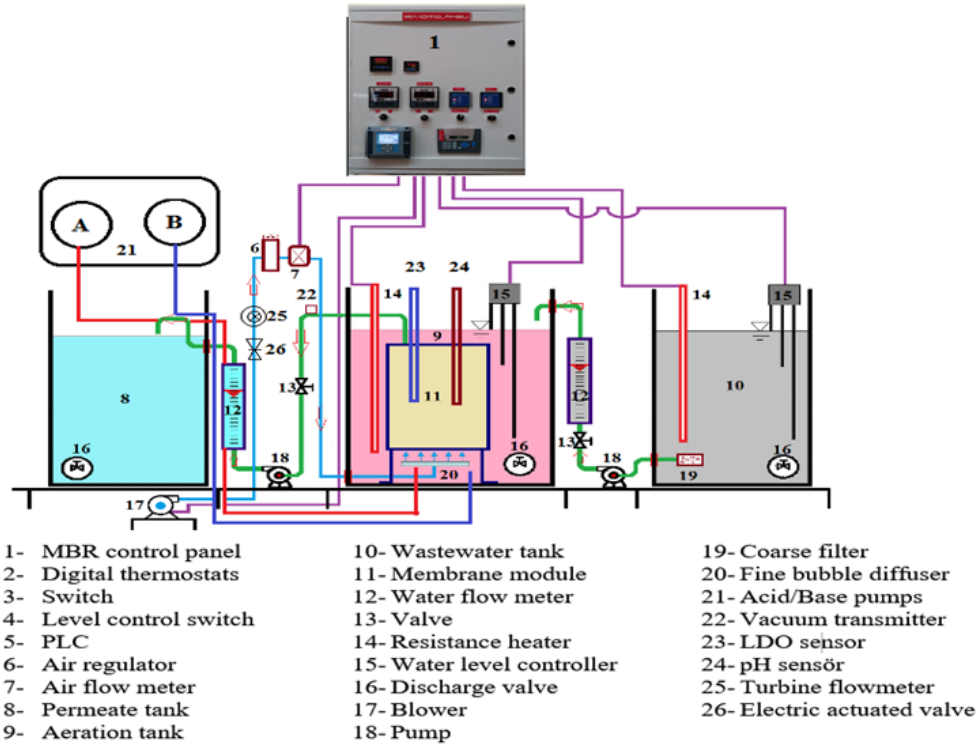

Figure 1. Schematic diagram of MBR system.

Activated sludge used in MBR system was collected from wastewater treatment facility in Bilecik First Organized Industry Zone, Bilecik, Turkey. It was acclimatized with influent wastewater for two weeks. The synthetic wastewaters as well as kitchen waste were used as influent and the synthetic waste water was made of 272 mg/L glucose, 97,1mg/L NH4Cl, 26,1mg/L KH2PO4, 10 mg/L CaC12, 10 mg/L

MgSO4. H20, 3 mg/L FeCI3, 200 mg/L NaHCO3. All chemicals were obtained from Merck. When the consumption habits in Turkey and the amount of solid waste generated per capita were taken into consideration, it is expected that total organic waste in a household of five members as 1.5 kg. Then, 7.2 % of it (108 g) would be used to flush with 5 L of water from sink, daily mixing of kitchen waste to municipal wastewater collection system. Some Japanese researchers [20-22] investigated the Japanese standard composition of garbage, which was adopted in this experiment. The component of kitchen waste were adjusted according to the availability in Turkey as presented in table 1.

Table 1. Kitchen waste composition

Component	Ratio (%) w/w	Wet weight /(g)
Carrot	18	19,44
Cabbage	18	19,44
Orange	10	10,80
Banana	10	10,80
Apple	10	10,80
Fish bone	8	8,64
Chicken bouillon	10	10,80
Eggshell	2	2,16
Meal waste	10	10,80
Used tea	4	4,32
Total	100	108,00

Samples were taken for analysis from wastewater tank, aeration tank and permeate outlet. COD, phosphate and nitrogen concentration analyses were carried out by means of a spectrophotometric test (Spectroquant Merck) and later determined spectrophotometrically (Nova 60A spectroquant) at 528 nm. Samples (influent, effluent) were centrifuged (Nüve NF 400) 5 min at 10000 x g and diluted appropriately before each COD determination. COD, phosphate and nitrogen concentration value were analyzed daily in influent as well as effluent to evaluate the removal efficiency. Ordinarily, the Sludge Volume Index (SVI) has characterized the sludge settling properties. SVI can be calculated using equation 1.

SVI = Settled sludge volume (mL/L) (1000)/ Suspended solids (mg/L) (Eq.1)

3. Results

The experimental works in the MBR system were carried for three runs. Samples were taken for analysis from waste water tank, aeration tank and permeate outlet. COD, phosphate and nitrogen concentration value were analyzed daily in influent as well as effluent to determine the removal efficiency. The MBR system removed COD at a high rate under three operating conditions, despite the fact that various levels of kitchen waste water had been discharged into the MBR system. In Variation of COD removal efficiency and SVI were given in Fig.2 and Fig 3, respectively.

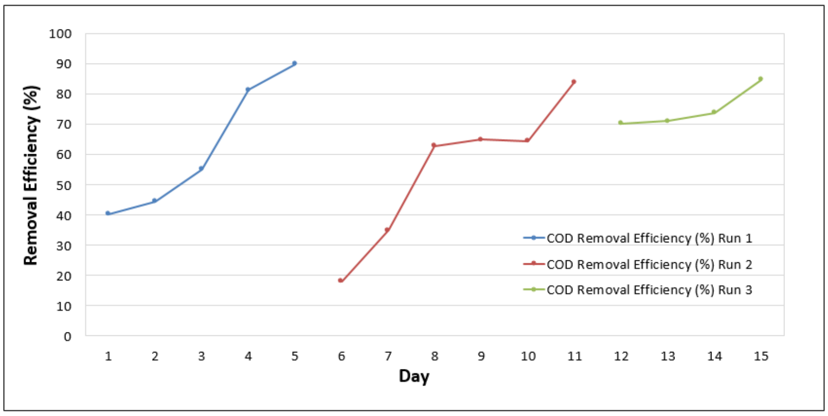

Figure 2. Variation of COD removal efficiency.

Influent COD of treating the synthetic waste water with domestic characteristics changed the within the range of 990 mg/L to 1140 mg/L. This variation resulted mainly because of kitchen waste in which COD varied. During the experiment, influent TKN and total phosphorous were varied in between 35-50 mg/L and 4-6 mg/L, respectively. Effluent average COD, TKN and total phosphorous were90-114 mg/L, 1.6-11.6mg/L and 0.04-0.19 mg/L, respectively.

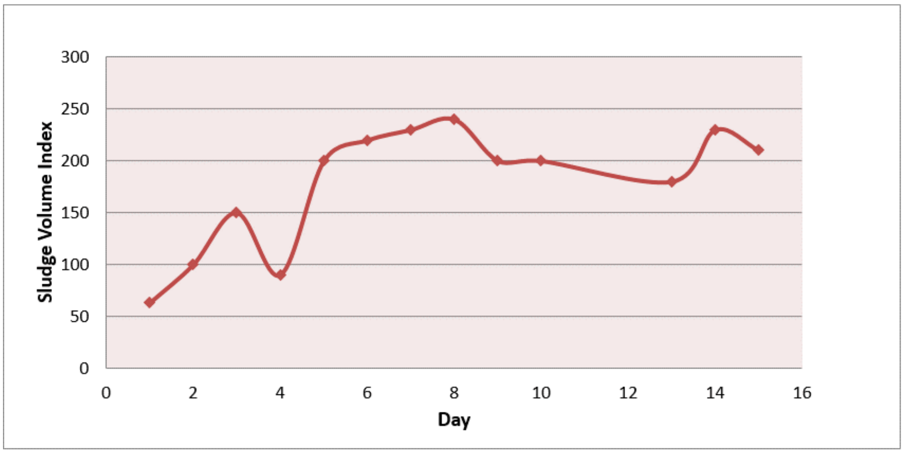

Figure 3. Sludge Volume Index variation.

As shown in the graph, SVI is more than 150 mL/g in activated sludge process. These results are typically relevant with filamentous growth[23]. Results clearly show that the MBR system could successfully reduce the COD, TKN and total phosphorous of domestic waste water.

4. Conclusions

As result of experimental studies, the removal efficiency of COD, phosphate and nitrogen was determined as %90; %88 and %91, respectively. The results obtained have exposed that by treating the waste water with domestic characteristics via a MBR system, the filtrate can be reused for fire hydrants, field irrigation, and toilet flushing.

Acknowledgment

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