Testing the Applicability of Submerged Hollow Fiber Membrane Bioreactor (MBR) Technology for Municipal Wastewater Treatment in Iraq

Dr. Talib R. Abbas
Ministry of Science and Technology/Baghdad
Mohammed A. Abdul-Majeed
Ministry of Science and Technology/Baghdad
Inmar N.Ghazi
Laser and Optoelectronics Engineering Department, University of Technology/ Baghdad
Email:omdaliain@yahoo.com

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ABSTRACT

Operation of a one module hollow fiber submerged type MBR system was tested in this work. The system was operated at fixed permeate flowrate of 12 l/hr. The hydraulic retention time of the aeration tank was about 8.3 hr. The mixed liquor suspended solid (MLSS) concentration was maintained in the range 5000-5500 mg/l. The results show the workability of this system under Iraqi conditions without any difficulties. About 85% chemical oxygen demand (COD) removal was achieved. The value of turbidity is well below 0.61 NTU throughout the operation time.

Keywords: MBR; Wastewater; Activated sludge; Hollow fiber membrane

أختبار تطبيق تقنية المفاعلات البيولوجية ذات أغشية الألياف المجوفة لمعالجة مياه الصرف الصحي في العراق

الخلاصة

تم في هذا العمل أختبار منظومة معالجة مياه صرف صحي بأستعمال تقنية المفاعلات البيولوجية ذات الأغشية. تم أستعمال قطعة غشاء واحدة غاطسة نوع الالياف المجوفة. تم تشغيل المنظومة بمعدل جريان ثابت للماء النافذ عبر الغشاء وبحدود 12 لتر/ساعة. كان الزمن البقاء الهيدروليكي للماء داخل خزان التهوية بحدود 8.3 ساعة. تم الحفاظ على تركيز المواد العالقة الصلبة للماء في خزان التهوية ضمن المدى 5000-5500 ملغم/لتر. أظهرت النتائج عمل هذه التقنية وفي الظروف العراقية وبدون مشاكل. بلغت نسبة الأزالة لمتطلب الأوكسجين الكيمياوي بحدود 85%. وكانت قيمة العكورة خلال فترة التشغيل أقل من 0.61 NTU.

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

INTRODUCTION

The lack of fresh water is becoming an increasingly serious problem in many Asian countries. The situation is aggravated further by the pollution of fresh water resources, such as rivers and groundwater due to discharge of untreated wastewater from industrial enterprises and municipal wastewater which are the main source of water pollution in most parts of Asia [1].

Recently, water resources in Iraq experienced deterioration in both quantity and quality [2]. Moreover, the existing centralized wastewater treatment plants are unable to follow the increasing load due to high rate of population increase. This situation necessitates a new wastewater treatment and water reuse management strategy based on small scale decentralized wastewater treatment plants.

In the last two decades Membrane Bioreactor (MBR) technology has grown exponentially because of advantages it offers over conventional treatment process such as; smaller footprint, advantageous effluent quality and better process control. It is expected that the demand for MBR systems will further increase with more than double digit growth annually over the next decade due to increasingly stringent regulations and huge demand in water reuse applications. In certain regions of the world, MBRs are already established as the key technology to protect and enhance sensitive surface waters or for water reuse [3].

Membrane bioreactor technology is an innovative wastewater treatment technology. It is an activated sludge process incorporating a membrane separation process for liquid-solid separation. There are two conventional types of MBR systems being used. One is a recirculated-type in which the membrane module is allocated outside the bioreactor. The other is a submerged MBR, in which membrane module is directly submerged into a bioreactor. In the later method, permeate of filtration is obtained by suction from a pump and air is generally supplied directly below the membrane module [4, 5].

In Iraq, Hospitals wastewater have the first priority to be treated using MBRs. The number of hospitals in Iraq is 231 in year 2007; more hospitals are being built every year [2]. It has been identified that hospital wastewater, especially from those treating infectious patients, contains a wide variety of microbial pathogens and viruses, requiring proper treatment and management before being discharged into receiving water bodies. Membrane technology is more efficient at removing pollutant [6] and pathological microorganism com-pared to other treatment systems. MBR technology presents a more efficient system at removing pathological microorganism com-pared with existing wastewater treatment systems. Higher disinfection efficacy is achieved in MBR effluents at lower dose of disinfectant with less disinfection by-products (DBPs) [7].

An experience and study deals with MBR technology to treat wastewater in Iraq is lacking. The main objective of this study was to gain experience and to assess the applicability of a submerged hollow-fiber MBR for wastewater treatment under Iraqi conditions.

MATERIALS AND METHODS

Figure (1) shows the schematic diagram of hollow fiber MBR system used in this study. The membrane module is a Polyethylene, hollow fiber, with nominal pore size of 0.4 µm and total active area of 1 m^2. Table 1 lists the main membrane module technical specifications. The membrane was developed and produced by the South Korean company Ssangyong Engineering and Construction Co., Ltd. The membrane is installed in a stainless steel tank (bioreactor) with dimensions of 100×10×150 cm with front side made of Perspex to facilitate visual monitoring of the membrane module. The aeration for the activated sludge is performs by fine air bubble distributor. A peristaltic pump was use to create a negative suction head at the membrane module to sustain the permeate stream flowrate. This pump was used in intermittent mode (on/off=10/1 min). The activated sludge level in the aeration tank was adjusted so that the total volume occupied by the activated sludge was about 100 L. Synthetic wastewater was fed continuously and effluent was withdrawn as well. In order to prevent rapid fouling, the membrane flux was maintained below the critical level. The system was operated at fixed permeate flowrate of 12 l/hr so that the hydraulic retention time (HRT) of the system will be about 8.3 hr.

The compositions of synthetic wastewater used in this study are summarized in Table (2). It was made by diluting a stock solution with tap water to obtain the desired COD. Synthetic wastewater contains the chemical compounds providing a source of carbon, nitrogen, and phosphorus and iron for biomass growth (Chang et al., 2006). The seeding sludge was supplied from secondary the clarifyer at Al-Rustumia wastewater treatment plant in Baghdad city (Iraq). After seeding, the sludge was cultivated with the synthetic wastewater over 1 month for acclimation of the miroorganisms.

The mixed liquor suspended solid (MLSS) concentration in the aeration tank was maintained in a range of 5000-5500 mg/l. The ambient temperature throughout the experiments period was in the range 15-25ºC. COD concentration was measured with DR2800-HACH Spectrophotometer. Turbidity was measured using turbidity meter Turb550-WTW. MLSS measurements were according to standard method [9].

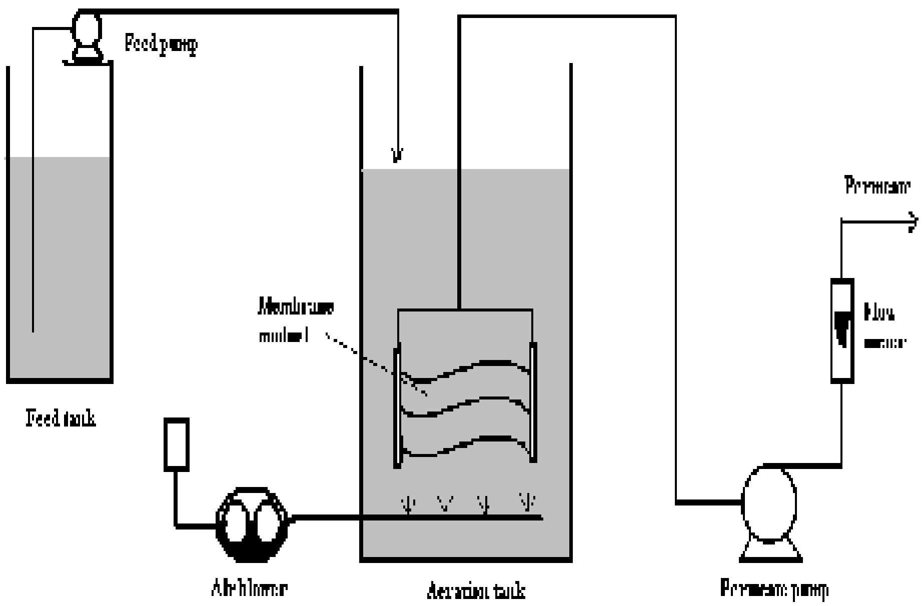

Figure (1): Schematic diagram of the MBR system used in this study

Table (1): Membrane module specification [8]

Item	Specification
Material	Polyethylene (semi-permanently hydrophilized)
Nominal pore size	0.4 µm
OD/ID/Wall thickness	650, 410, 120 µm
Operation flux	0.3 m^3/m^2.day
Operation pressure range	-5 cm Hg - -40 cm Hg
Critical pressure	-45 cm Hg

Table (2): Composition of the synthetic wastewater [4]

Composition	Concentration (mg/l)
Sodium Citrate	300
Urea	96
K_2HPO_4	42
$FeCl_3.6H_2O$	21

RESULTS AND DISCUSSION

The influent and effluent water COD with time are shown in Figure (2). The influent COD concentration ranges from 142 to 149 mg/l while the effluent COD concentration ranges from 11 to 20 mg/l. It is clear that about 85% COD removal can be achieved in this system. The significant COD removal is attributing to high MLSS concentration in the aeration tank and to the membrane prevention efficiency of particulate organic matter from permeation with effluent water. This result is in consistent with that given by other studies [10, 11]. The effluent water was slightly colored. Similar note was mentioned by Tam et al. [12].
Fig. 3 shows the effluent water turbidity with time. The value of turbidity is below 0.61 NTU throughout the operation time. This value of the turbidity reveals that the effluent water is quite clear and suitable for reuse purposes such as irrigation or toilet flushing after disinfection. The stable and low effluent water turbidity means that hollow fibers of the membrane module worked well without any defect throughout the operation period.

CONCLUSIONS

The results of this study show the workability of MBR process using hollow fiber membrane module under Iraqi conditions without any difficulties. The effluent water quality in terms of COD and turbidity is suitable for reuse purposes after disinfection. Pilot plant with higher flowrate to treat actual municipal wastewater or hospital wastewater in parallel with an existing convention activated sludge wastewater treatment plant is needed to verify the applicability of MBR technology to treat municipal and hospital wastewater in Iraq so that decentralized plants can be started to recover water at the source of pollution.

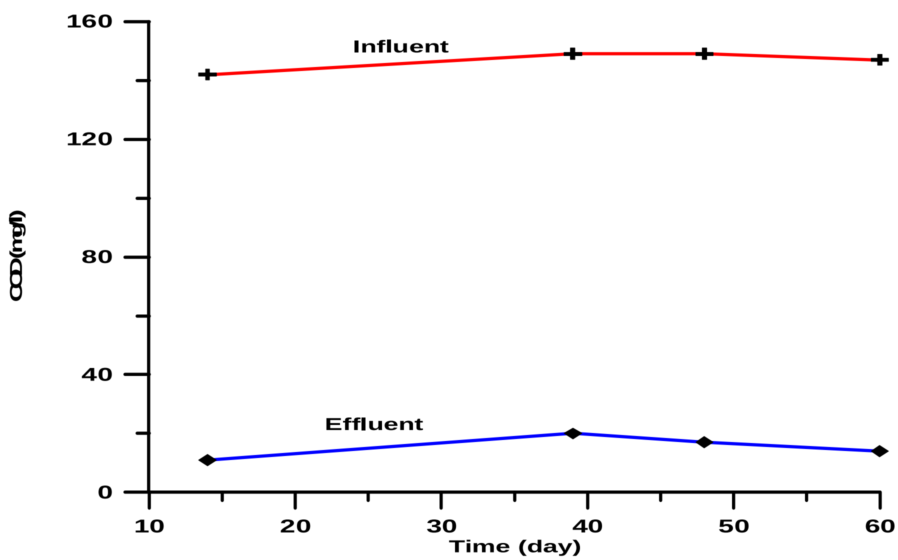

Figure (2): Influent and effluent water COD with time.

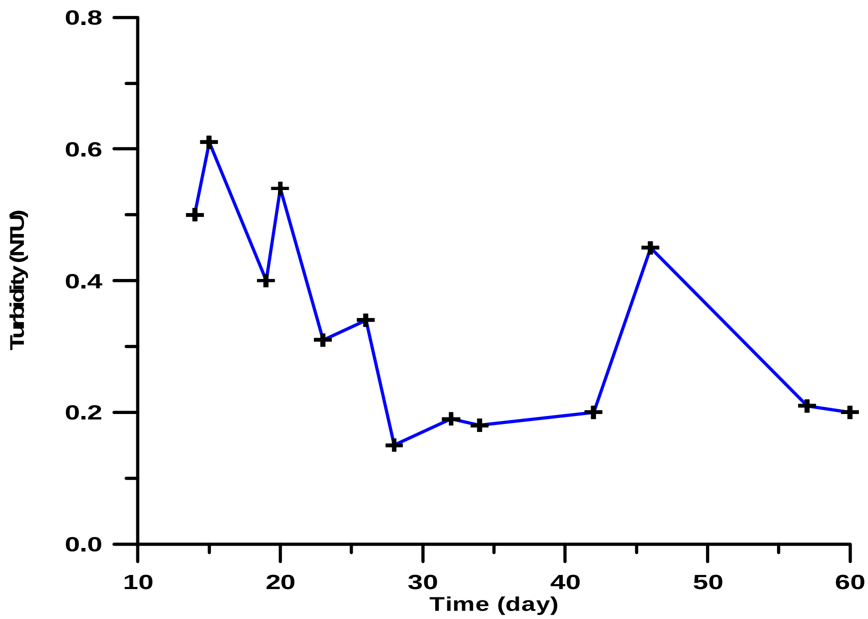

Figure (3): Effluent water turbidity with time.

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