JEE Journal of Ecological Engineering

Journal of Ecological Engineering 2023, 24(10), 205–213
https://doi.org/10.12911/22998993/170085
ISSN 2299–8993, License CC-BY 4.0

Received: 2023.07.03
Accepted: 2023.08.03
Published: 2023.08.21

Evaluation of the Efficiency of the AL-Mauany Hospital Sewage Treatment Plant in Basrah City

Samar A. Al-Khafaji[1], Wisam S. Al-Rekabi[1*], Sarmad A. Abbas[1]

[1] Department of Civil Engineering, College of Engineering, University of Basrah, Iraq

* Corresponding author's e-mail: wisam.neaamah@uobasrah.edu.iq

ABSTRACT

This study focuses on assessing the sewage characteristics and performance of the Hospital Wastewater Treatment Plant for AL-Mauany hospital in Basrah Governorate. Samples were taken from wastewater treatment plants (WWTP) waste and tested for pollutants using (APHA) procedures and compared to standard criteria. COD, BOD, temperature, EC, TSS, and TDS were all tested in the laboratory. DO, NH_3, and NO_3 were chosen as effluent quality indicators. Identical to the standard limits in Iraqi Standard Specification, despite some of them experiencing a minor modification during the treatment stages. But for COD and BOD, which exceeded the permissible limit despite the high removal efficiency, because the values at the entrance were high because they came from hospital waste, where the values at the influent were for COD 665.4 mg/l and 504.6 mg/l, while the BOD values were 283.6 mg/l and 171.2 mg/l in summer and winter, respectively, while the effluent values were 129.7 and 102.8 for COD and 73.4 and 53.8 for BOD. As well as for the NO_3-N results for the effluent, which was unstable inflow and effluent, but in no way did it exceed the Iraqi effluent which was 50 mg/l.

Keywords: hospital wastewater treatment, MBR, removal efficiency, organic matter

INTRODUCTION

Water recycling treatment technology offers a wide range of alternatives. Membrane processes have emerged as the key to sophisticated sewage renovation and reusing plans, and they are used in a variety of internationally well-known plans, such as those for the production of industrial process water, indirect potable reuse, and artificial groundwater replenishment. Membrane bioreactors (MBRs) are a promising technology that combines membrane filtration for biomass retention with activated sludge treatment. When paired with other cutting-edge treatment methods, wastewater reclamation using MBR technology is the preferred approach, according to many studies [Ajay et al., 2017; Wisniewski, 2007]. In the secondary activated sludge phase of a sewage treatment plant, a membrane bioreactor can be used to reuse water from wastewater.

Membrane bioreactor activity may be traced back to the 1960s. However, the practical use of the membrane in wastewater treatment has stayed constrained, owing principally to poor membrane flow, low permeability, short membrane life, and expensive membrane cost. A new membrane generation appeared at the start of the 1990s as a result of vigorous study in the area of membrane engineering, which dramatically resolved many of the aforementioned limits, and membrane costs began to fall. This has sparked considerable interest in the commercial application of membranes in wastewater treatment. By then, membranes were widely used in other applications in industry, involving water treatment, and a great deal of expertise had been gained [Scott and Smith, 1996; Al-Khafaji et al.,2022].

The prevention of the expansion of (multi-resistant or pathogenic) bacteria, viruses, and egg parasites in addition the input of medications, diagnostic tools, and disinfectants are considerations in the case of hospital wastewater. One alternate approach to the design of small wastewater treatment facilities is the membrane bioreactor technology. The bioreactor, which incorporates a membrane technique and biological treatment procedures into one device, is intended to filter out particle, colloidal, and dissolved materials from liquids [Mousaab et al., 2014]. It is widely acknowledged that membrane performance is decreased by fouling.

Hospital wastewater is waste generated by hospital chores like medical and non-medical first-aid tasks, as well as emergency, diagnostic radiology, laboratory, laundering, and food operations [Majlesinasar, 1998]. In hospital wastewater, hazardous contaminants such as partially metabolized pharmaceuticals, pathogenic bacteria, poisonous chemical compounds, and radioactive components can be discovered [Rezaee et al.,2005].

Murray et al. [2005] proposed using MBR treatment for beverage industry effluent. The MBR method was chosen because of its capability to deal with highly variable, high-temperature, strong sewage lacking the requirement for settlement. Due to the constrained space and high-quality water for reusing, MBR was the perfect solution. The gathering effluent had an erratic nutritional profile that was rich in H, O, and S. The control of nutrients had a major impact on process efficiency inside the MBR. Upon startup, the gadget had a flux pressure of 26 gal/ft^2.d, and cleaning every 2 to 7 days was necessary. The correction for nutrient shortage increased the flow rate to 53 gal/ft^2.d and dropped the cleaning criteria to once every thirty days.

Mohammed Ali et al. [2014] employed an ultrafiltration flat sheet membrane model with a submerged MBR (SMBR) process of the MLE type. With removal efficiencies of 96, 98.4, 99.5, and 98.33% for nitrogen, BOD_5, TSS, and pathogens, respectively, this model exhibits excellent pollution removal from hospital wastewater for all measured parameters when compared to the CAS system, yielding average effluents of 6.75, 10.4, 1.0 mg/l, and 13 MBN/100 mL, respectively.

Al-Dulaimi and Sufyan [2002] provided an explanation using a study he carried out to assess the effectiveness of treatment facilities at three hospitals in Mosul. According to this study, the sewage treatment plant at Al-Khansaa Hospital had an important decrease in removal efficiency, which is dependent on treating activated sludge, and this decrease was caused by many probing factors. This hospital wastewater has characteristics that are similar to those of domestic wastewater.

Mousaab et al. [2014] studied the influence of pharmaceutical compounds present in the effluents hospitalized. The MBR achieved very high organic removal efficiency. The findings of the pharmaceutical ingredient dosage showed that the MBR had high removal efficiency for more than ten distinct compounds. Like the total and soluble COD removal efficiencies were always more than 87.9% and 86.9%, respectively. TSS and VSS concentrations in the MBR increased virtually continually throughout the startup (depending on our wastewater parameters, the growth was modest and not particularly noticeable). The concentrations of particles in the effluent were always very low (0.0012 g/L), indicating the superior solids removal of micro-filtration systems. The elimination of TSS was 99.5% obtained only through membrane filtering, indicating the membranes' excellent solids retention capability. In addition, over 97% of the VSS influent was eliminated. Nitrogen removal efficiencies must be given special consideration. The total and soluble nitrogen removal efficiencies were always more than 91% and 90%, respectively.

Al-Ani et al. [2019] utilizing experimental pilot plants for research aims to better understand the kinetics of biologically mediated processes as well as the complicated biological phenomena mediating nutrient removal processes in membrane bioreactor – biological nutrient removal MBR BNR systems. In terms of removing TSS, the MBR arrangement performed noticeably better than conventional activated carbon (CAS) and university of Cape Town CAS and UCT. During operation, the MBR's TSS removal efficiency was almost 100%, and the TSS content in the effluent stayed below.

Abbas et al. [2021] was meant to evaluate how well the sewage treatment unit in Al-Thagher city is operating, which is located in the northern region of southern Iraq's Basrah Governorate. A study of influent and effluent wastewater quality data from February 2017 to December 2018 was used to determine the plant's performance. The results indicate that all samples of the plant's effluent that were collected met the Iraqi water quality standard (IWQS) for temperature, pH, ammonia (NH_3-N), chemical oxygen demand (COD), and biological oxygen demand (BOD). While electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), sulphate (SO_4^{-2}), chloride (Cl^{-1}), and phosphate (PO_4-P) sometimes met sometimes failed to meet the Iraqi water quality standard. The following is the order in which the average removal efficiencies were: COD (77.12%) is higher than BOD (77.03%), TSS (62.26%), NH_3-N (59.99%), PO_4-P (12.42%), and Cl^{-1} (1.97%), in that order. The goal of this study is to learn more about the features of hospital wastewater as well as the efficiency of AL-Mauany Hospital.

METHODOLOGY

The term "membrane bioreactors" is currently most frequently used to describe these systems. The MBR is a beneficial option to other treatment methods due to a number of advantages that come with it. First of all, the bioreactor's ability to retain all suspended matter and the majority of soluble substances results in outstanding effluent quality that can pass strict discharge standards and pave the way for direct water reuse.

A sterile effluent is produced when all bacteria and viruses are retained, reducing the need for thorough disinfection and the associated risks associated with disinfection byproducts. Microbes extract nutrients and organic carbon from sewage during the biochemical stage of sewage treatment. These microorganisms develop and reside embedded in EPS, which groups them into distinct microcolonies to create flocs, which are three-dimensional aggregated microbial structures. The formation of flocs by microorganisms is essential for the wastewater treatment process using activated sludge. The floc structure facilitates the adsorption of colloidal particles and macromolecules that are additionally present in wastewater, in addition to the adsorption of soluble substrates. In activated sludge, there is a very diverse microbial community that includes bacteria, protozoa, nematodes, rotifers, and viruses. Bacteria dominate the microbial population in this intricate microsystem and are essential to the degradation process.

MBR technology implies a continuous synthesis of fresh sludge with the consumption of feed organic materials, with the biochemical and sludge-separation stages merged into one phase, while some sludge mass is eliminated by endogenous respiration. Consumption of cell-internal substrate occurs during endogenous respiration, which results in a decrease in activity and a modest reduction in biomass. By taking into account related respiration under aerobic conditions, such as decay, maintenance, endogenous respiration,

Figure 1. Site location and process description Al-Mauany wastewater treatment plant

lyses, predation, and death, endogenous respiration indicates all forms of biomass loss and energy requirements not linked with growth.

It can be both aerobic and anoxic, but the former is much slower and the latter, particularly for protozoa, is much less active while denitrification is occurring (slower predation). Very high sludge age, or high sludge concentration, can promote the endogenous respiration of a microbial population in an MBR. The amount of substrate accessible to bacteria affects their access to energy. Theoretically, it would be possible to achieve a condition where the amount of energy supplied is equal to the maintenance need by increasing the SRT, which raises biomass concentration.

The MBR has some drawbacks, primarily financial ones. The system has been characterized by high energy costs because a pressure gradient is necessary and high capital costs because of pricey membrane components.

The membranes may need to be cleaned frequently as a result of concentration polarization and other membrane fouling issues, which would require clean water and chemicals and cause the membranes to stop working. Problematic waste disposal of activated sludge can be another issue. Waste-activated sludge AS may have poor filterability and settle ability qualities because the MBR retains all suspended particles and the majority of soluble organic materials.

Al-Mauany wastewater treatment plant, is located in the south of Iraq. The plant receives hospital wastewater with industrial liquid wastes. Mechanical and manual coarse screens, as well as velocity-controlled grit chambers, are used in the pre-treatment facilities. Figure 1 depicts the present minor part units, which include multiple parallel membranes and a chlorine contact basin, as well as an aeration blower, an oil trap, and final treatment water pipes.

The region has two types of climates: hot, dry climate in summer and moderate, rainy in winter. The average monthly air temperature in the period of study ranges from 10 °C to 45 °C.Were collected influent and effluent samples to assess the effectiveness of the WWTP at Al-Mauany Hospital; the biological approach employed to treat wastewater in this hospital was MBR. Dissolved oxygen (DO), pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), temperature, electric conductivity (EC), turbidity (Tur.), total suspended solids (TSS), total dissolved solids (TDS), ammonia (NH_3), and nitrate (NO_3) were the contaminants studied in this study. This research would help to improve the effectiveness of wastewater treatment systems based on wastewater characteristics.

Were performed every ten days for 3 months during the summer and three months in the winter. As a results some of the parameters exceed the permissible limits according to the Iraqi standard, such as NO_3, and this may be due to the method and times of operation of the treatment plant in the hospital, or it may be due to the different loads received from the station from time to time because the rain network and the network of the magazine in it are linked together.

MATERIALS AND METHODS

Sample gathering for this research, Samples were taken at the WWTP's influent and effluent in glass containers using [APHA, 1992]. Samples were collected once every 10 days (9 a.m.) in May to July for the first stage, and once every ten days from November to January for the second stage. The majority of the tests were performed immediately after the samples were collected with a field device, and the rest duplicate samples were held in a refrigerator at 4 °C in the sanitary laboratory at the College of Engineering, University of Basrah.

ANALYTICAL PROCEDURE

A digital metal was used to detect dissolved oxygen, electrical conductivity, temperature, and pH (the instrument was calibrated using standard solutions prior to measurement). Chemical oxygen demand and biochemical oxygen demand, total suspended solids, total dissolved oxygen, ammonia, and nitrate were measured using the procedures indicated in the American Public Health Association's Standard procedures for the Examination of Water and Wastewater [APHA, 1992]. The samples are analyzed using DR5000, DR1900 Hach spectrophotometric instruments, and SpectroDirect Lovibond. When the test needs it, filtered sewage samples through paper (pore size 0.45 Mm). All tests were carried out at a room temperature of 25 °C.

RESULTS AND DISCUSSION

Basrah (in southern Iraq) contains many hospitals, and the wastewater treatment plants in the majority of these hospitals were biological. The findings of this study were shown in Table 1. Any pollutant's conversion or removal efficiency equation is determined as follows [Rumana, 2013; Metcalf and Eddy, 2003]:

$$\% \text{ removal efficiency} = Ao \cdot At / Ao \quad (1)$$

where: Ao – initial pollutant concentration, mg/L; At – pollutant concentration after time t, mg/L.

A study of the data revealed that several parameters, such as COD, BOD, DO, and nitrogen compounds, changed significantly during treatment (Table 1 and Figure 2 to Figure 11). However, in the summer, the pH of the raw influent and effluent was found to be somewhat acidic (7), which gradually switched towards alkalinity (8) in the winter. DO was essentially absent at the inlet but steadily increased (7 mg/l) throughout the treatment. The EC remains below the permissible limits of the sewage plants when the wastewater passes through several phases of the treatment facility. COD and BOD5 levels were also reduced during treatment. However, the removal effectiveness of COD and BOD in MBR decreased throughout treatment (80% and 79%) for COD and (74% and 69%) for BOD in summer and winter, respectively, BOD_5/COD ratio is 0.56 and 0.52 of effluent in two period respectively indicates the bio-treatability of sewage The removal efficiency of NH_3-N was (86% and 83%), which was good and within the limits of the required specification, but no such change in efficiency was found in the treatment plant for NO_3-N (Figure 7), which demonstrated irregularity during the treatment. Its concentration increased as the wastewater moved from the inlet to the outlet. This may be due to the high dissolved oxygen in the outlet.

Parameter like Turbidity also displayed a substantial reduction during the treatment, removal efficiency was 70% in summer and 66% in winter. But, the values of suspended solids did not witness an acceptable removal after the final stage, possibly due to the accumulation of biofilm in the aeration basin, and therefore to the subsequent treatment stages, where its values were greater than the values specified in the Iraqi standard. In some parameters, insignificant variation was recorded, such as TDS (Table 1 and Figure 10). It is important note that the values of the TDS were volatile as the value of effluent increased or decreased. Compared to influent, but as an average for all readings, there was a relatively slight increase in the value of the effluent TDS. This is probably because of continuous temporal variation of influent TDS which may be mixed with the high concentration present in the tank (from previous period) this can result in a high effluent TDS. Generally MBR unit has no rule in removing TDS. It was noted that most of the parameters are affected by the high temperature during the summer, such as the high concentrations of COD and BOD, and the reason may also be the high number of patients in the hospital, which increases the concentrations of these parameters. On the other hand, some

Table 1. the average parameters concentration in the influent and effluent WWTPs, as well as the removal efficiency percentage and quality standard

Parameter	Unit	Summer			Winter			Quality standard
		Influent	Effluent	Removal rate %	Influent	Effluent	Removal rate %	
pH		7.1	7.4	–	8.3	8.3	–	6-9.5
DO	mg/l	0.4	6.7	–	0.9	7.5	–	–
EC	µs/cm	3169.9	3248.0	–	2213.2	2236.0	–	–
COD	mg/l	665.4	129.7	80%	504.6	102.8	79%	100.0
BOD	mg/l	283.6	73.4	74%	171.2	53.8	69%	40.0
NH_3	mg/l	16.9	2.3	86%	12.3	>2	83%	10.0
NO_3	mg/l	14.8	39.7	–	15.3	36.3	–	50.0
Turbidity	NTU	106.1	31.2	70%	134.0	45.4	66%	–
TSS	mg/l	417.6	99.6	76%	433.4	104.5	76%	–
TDS	mg/l	2148.8	2416.4	–	1929.7	2023.4	–	–

of the parameters are inversely proportional to the temperature, as they decrease with increased temperature, such as PH and DO.

NOTE: All the figures on the left represent the results of tests in the summer and on the right the results in the winter.

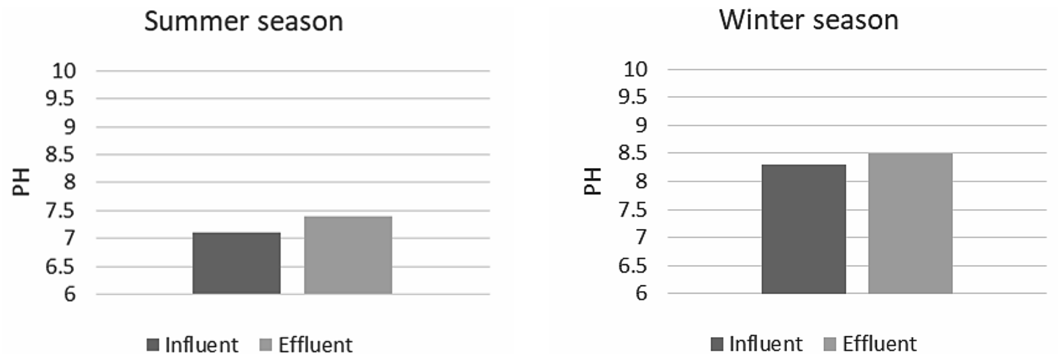

Figure 2. Variation of PH in summer and winter

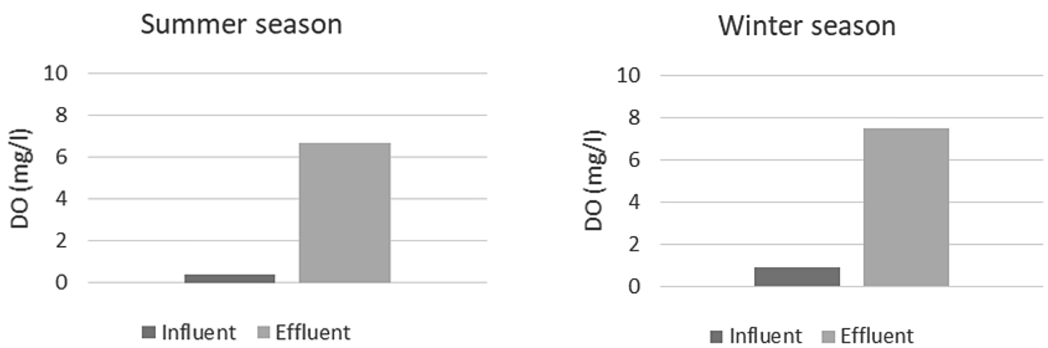

Figure 3. Variation of DO in summer and winter

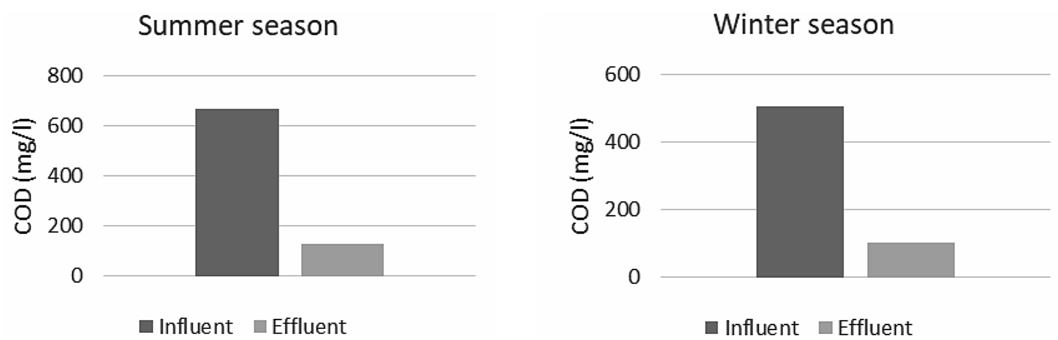

Figure 4. Variation of COD in summer and winter

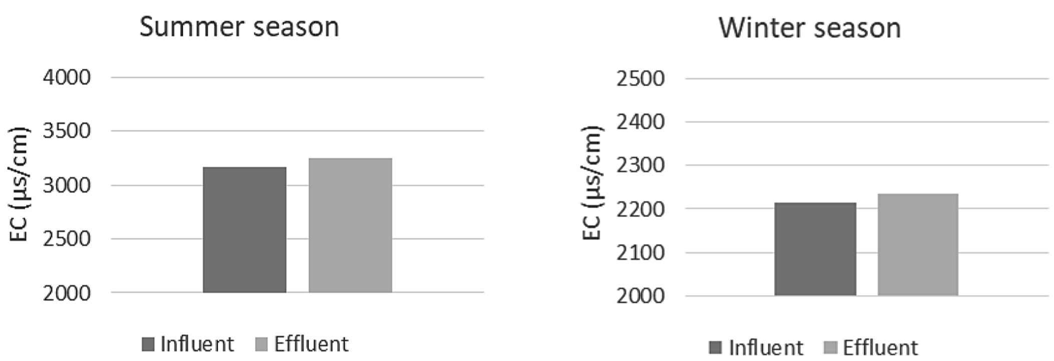

Figure 5. Variation of EC in summer and winter

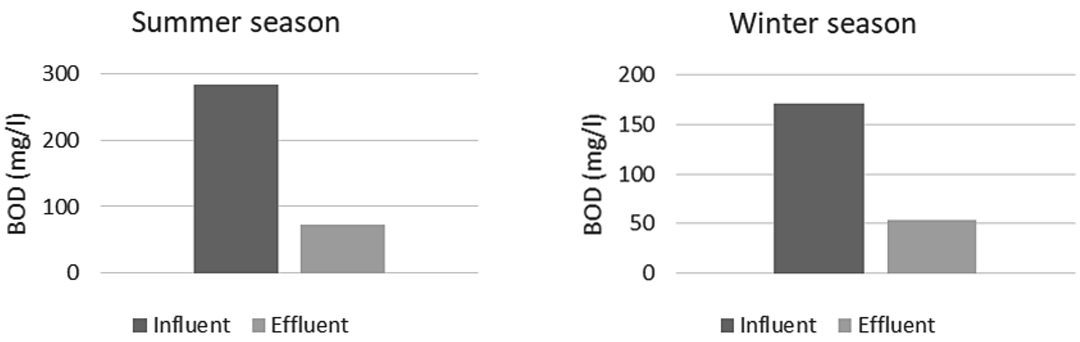

Figure 6. Variation of BOD in summer and winter

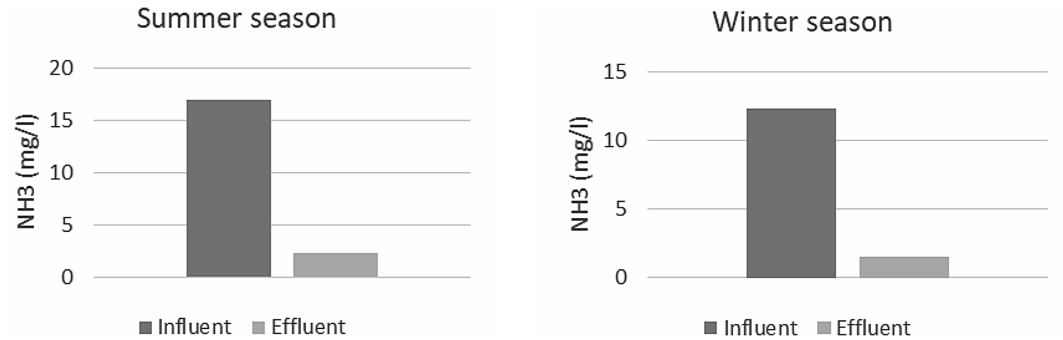

Figure 7. Variation of NH_3 in summer and winter

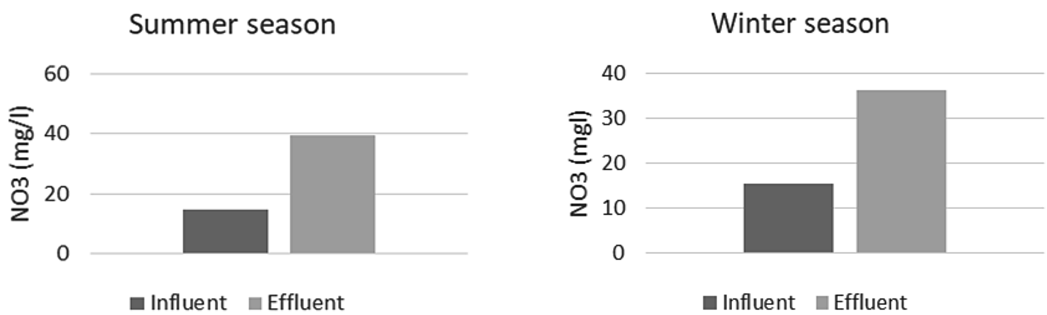

Figure 8. Variation of NO_3 in summer and winter

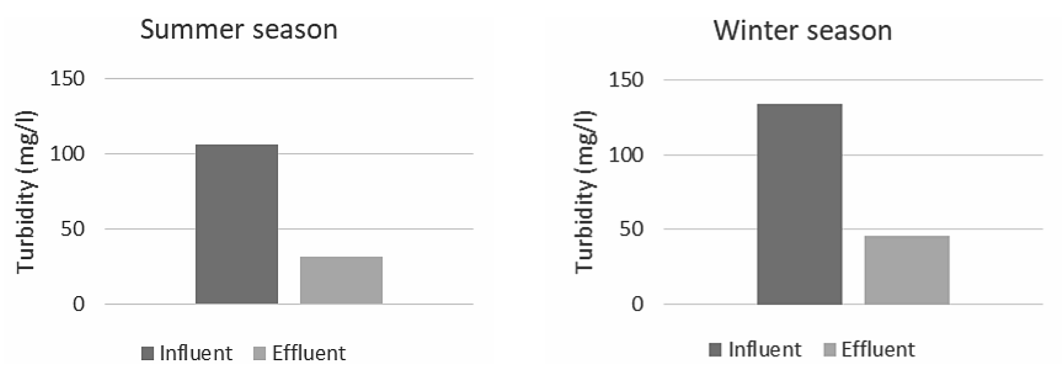

Figure 9. Variation of Turbidity in summer and winter

CONCLUSIONS

By utilizing various techniques, numerous researchers have attempted to establish the membrane bioreactor system for the treatment of hospital wastewater. High effectiveness in removing various constituents, such as pH, biochemical oxygen demand, chemical oxygen demand, temperature, electric conductivity, total dissolved solids, total suspended solids, dissolved oxygen,

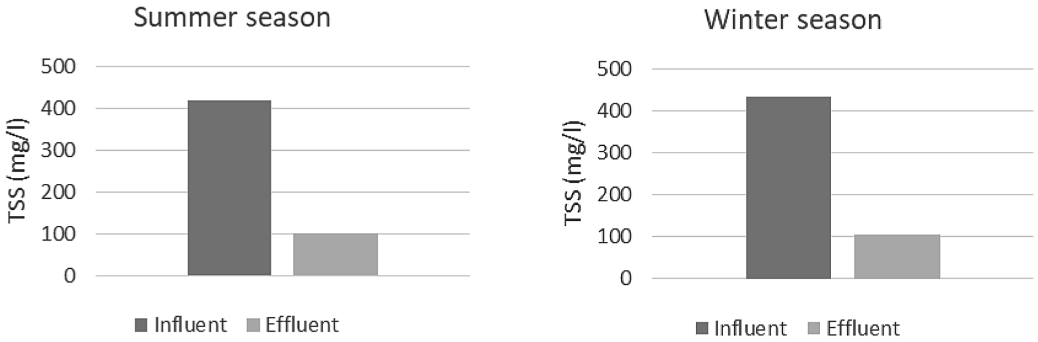

Figure 10. Variation of TSS in summer and winter

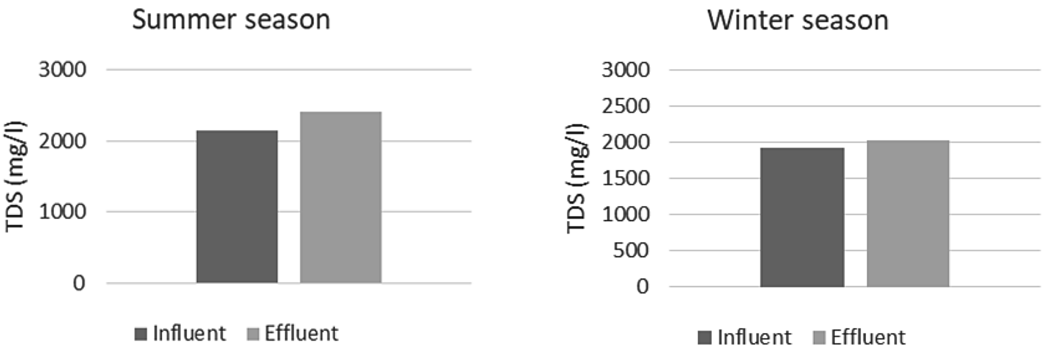

Figure 11. Variation of TDS in summer and winter

ammonia, and nitrate are the parameters used to evaluate wastewater quality. However, using the MBR system has increased significantly in recent years, due to its advantages. Even though the hospital sewage was diluted and treated in a sewage treatment plant, laboratory tests revealed that some wastewater parameters still exceeded Iraqi standards. Basrah hospitals utilize WWTPs, which have benefits and drawbacks in terms of overcoming pollutant concentrations of COD, BOD, and other parameters, but are ineffective in reducing NO_3-N pollutant concentrations. Overall, the results showed that most contaminants were removed effectively.

REFERENCES

1. Abbas, A., A, Yousif, Y., T, and Almutter, H., H.2021. Evaluation of Al-Thagher Wastewater Treatment Plant. Periodica Polytechnica Civil Engineering, 66 (1), 1–15.
2. Ajay P. Pardey, Dr. V. S. Sapkal, Dr. R. S. Sapkal, 2017. A Review on Membrane Bioreactor (MBR) Technology: Its Commercial Applications And Possibilities of Hybridization with Other Membrane Techniques to Recover Valuable Industrial By-Products for Sustainable Development and Environmental Protection by and Large. ICSESD- Proceedings IRA-International Journal of Technology & Engineering.
3. Al-Dulaimi A. and Sufyan M. Saeed.2002 .Evaluation of the Efficiency of Biological Treatment of Some Hospitals in the City of Mosul. Master Thesis, College of Engineering, University of Mosul, Iaq.
4. Al-Khafaji, S., A, Al-Rekabi, W.,S, and Mawat, M.,J.2022. Apply Membrane Biological Reactor (MBR) in Industrial wastewater treatment: A Mini Review. Eurasian Journal of Engineering and Technology, 7, 98–106.
5. APHA.1992. American Public Health Association. Standard Methods for the Examination of Water and Wastewater. 18th Edition. American Public, Health Association, Washington, D.C.
6. Faris H. Al-Ani, Hasan Sh. Majdi, Jamal M. Ali, Ayham M. Al Rahawi, Qusay F. Alsalhy.2014 .Comparative study on CAS, UCT, and MBR configurations for nutrient removal from hospital wastewater. Desalination and Water Treatment, 164,.39–47.
7. Majlesinasar, M.1998 .Study of Wastewater Disposal Status and Effluent Quality in Hospital of Shahid Beheshti University of Medical Sciences. Iranian Journal Publ. Health, 6 (1), 371-375.
8. Metcalf and Eddy.2003. Wastewater Engineering: Treatment and Reuse. Fourth edition. McGraw-Hill, Inc., New York.
9. Mohammed Ali I. Al-Hashimia, Talib R. Abbas, Yaser I. Jasema.2013. Performance of sequencing anoxic\ anaerobic membrane bioreactor (SAM)

system in hospital wastewater after treatment and reuse. European Scientific Journal, 9 (15).

10. Mousaab Alrhmoun, Claire Carrion, Magali Casellas, and Christophe Dagot.2014. Hospital wastewater Treatment by Membrane Bioreactor: Performance and Impact on the Biomasses. International Conference on Biological, Civil and Environmental Engineering (BCEE-2014) Dubai (UAE), 17-18.
11. Murray, C.W.; Abreu, L.H.; Husband, J.A.2005. Three Liters of Soda in a Two Liter Bottle: The use of Membrane Bioreactors at a Bottler's WWTP. Conference Proceedings 2005 AWWA Membrane Technical Conference.
12. Rezaee A. Ansari M., Khavanin A., Sabzali A., and Aryan M.2005. Hospital Wastewater Treatment Using an Integrated Anaerobic Aerobic Fixed Film Bioreactor. American Journal of Environmental Sciences,.4 (1), 259-263.
13. Rumana R. 2013.Fundamentals of Wastewater Treatment and Engineering. International standard book. IWA Publishing, London.
14. Scott, J.A.; Smith K.L.1996. A Bioreactor Coupled to a Membrane to Provide Aeration and Filtration in Ice-Cream Factory Wastewater. Water Resources, 31(1), 69.
15. Wisniewski, C.2007. Membrane bioreactor for water reuse. Desalination, (203), 15-19.