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Research Article

Evaluation of MBR Application in Comparing with Conventional Wastewater Treatment of Industrial Wastewaters

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ABSTRACT

Membranes are considerably a physical technology for wastewater treatment, which has existed since the 1960s. However, membrane technology has increased and extended in application in recent years and this technique was promising treatment technologies. This is partly due to strong regulations in industrialized countries regarding effluent quality as well as increasing global water scarcity. Because of the water scarcity in the Middle East countries, these countries need to treat the wastewater for another uses and purposes such as irrigation. The present study aimed to compare the convention wastewater treatment and the membrane bioreactor technology in treatment of municipal wastewater. The observation showed that the removal percentages of COD, BOD, TSS, ammonia, TN, TP, oil & grease and phenol were between 92.5 to 99.8%, while the removal percentages in conventional treatment were between 81.0 to 93.2%, the results of the MBR effluent were complying with Egyptian regulation while many parameters didn`t comply with Egyptian regulation in case of conventional treatment.

Keywords:Performance; MBR;Conventional wastewater treatment

INTRODUCTION

Membrane bioreactor (MBR) is a treatment process which compromise from both biological treatment and membrane separation [1].

MBRs have been developed in the 1960s, after membrane science had made major advances with the invention of asymmetric cellulose acetate membranes [2] and MF and UF membranes became commercially available. Flat sheet membranes were early used for MBRs which mounted in a side-stream configuration (Figure 1). MBR firstly used for treatment of wastewater on board of ships, that developed by Dorr Oliver [3]. However, MBR membranes were still very expensive, and had a short lifetime and the MBRs may subject to membrane fouling [4,5].

In the 1990s, MBRs had their breakthrough, driven by a combination of factors: improved and less expensive membrane material made the process more economic. Additionally, submerged MBRs were invented, which helped to further decrease the operational costs for larger scale applications [5]. Further on, stricter legislation on water discharge quality for municipal wastewater treatment plants required improved treatment technology. In combination with local water scarcity and the growing awareness for the benefits of water reclamation from wastewater, this lead to a rapid increase in MBR plant installations [6].

In a classic sewage treatment process (Figure 1), pretreatment of the wastewater, including the removal of larger objects and coarse material, is followed by primary treatment in sedimentation tanks or clarifiers to remove settle-able solids and floating scum. In the secondary treatment step, the conventional activated sludge process (CAS); organic material is degraded by microorganisms in aerated basinets. The microorganisms accumulate into flocs, which are suspended in the wastewater. After the treatment step, the flocs are then removed from the liquid in a secondary settler. However, this process depends on easily settle-able flocs and can be disturbed by variations in wastewater volumes or composition.

Here, MBRs (Figure 2) can replace secondary treatment and offer many advantages: MBRs enable the decoupling of SRT and HRT, because the biomass is retained in the bioreactor by the membrane. This allows for longer SRTs, which benefits slow-growing nitrifying bacteria or methanogenicarchaea and results in better biodegradation of organic material, while HRTs can be kept short [7]. MBRs can replace biological treatment and gravitational settling or clarifier, because they can handle larger concentrations of solids than CAS systems, which are limited by the sedimentation rate [8]. Since MBRs eliminate the need for large sedimentation tanks, they are relatively compact plants and have been reported to require up to 50% less space in comparison to conventional wastewater treatment plants [8]. This is often a crucial requirement for selecting a wastewater treatment process on industrial sites [9].

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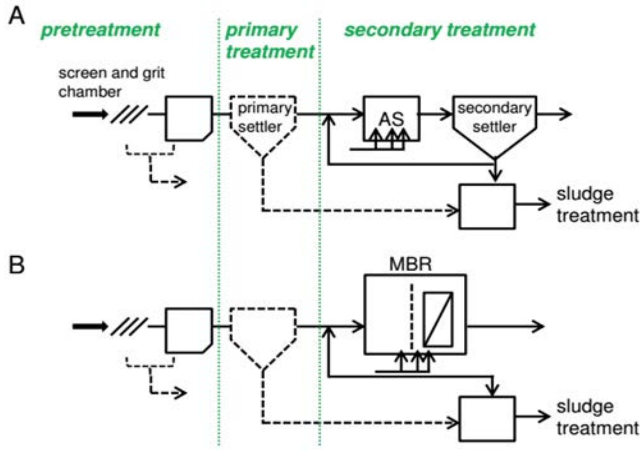

Figure 1: Comparison of a (A) typical sewage treatment process with a conventional activated sludge (AS) treatment and (B) membrane bioreactor (MBR) process.

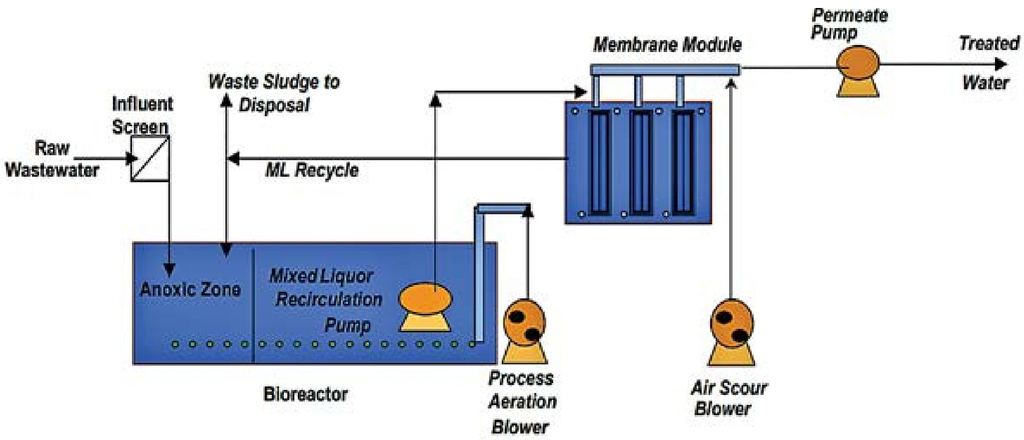

Figure 2: The MBR Process.

Due to the small pore size of MF/UF membranes, suspended solids and organic matter are efficiently removed from the wastewater, so MBRs are also able to produce high quality effluent, which can then be re-used for non-potable applications [6]. This is an advantage in areas where fresh water is in short supply or for wastewater treatment plants located in protected nature, where demand on effluent quality for discharge is high.

Down-sides of MBR technology include relatively the requirement for pretreatment to prevent membrane damage from coarse material, high energy requirements and capital expenditure as well as the requirements for highly trained personnel [10]. Further on, membrane fouling, which decreases membrane performance and therefore process productivity [11], is still an issue, shortening membrane lifespan and driving up operational costs, when membranes have to be cleaned or replaced. MBR technology is still more expensive than CAS, but costs go down as more MBR plants are implemented. Additionally, MBR technology is still perceived as "novel", with MBR equipment being unique to each supplier, which hinders a more wide-spread implementation [9]. However, as MBR knowledge becomes more widespread, confidence in the technology increases and membrane prices drop, thereby further reducing operational costs, MBRs are expected to become rapidly more widespread.

The two most common MBR process configurations are displayed in Figure 2. Both side-stream (A) and submerged MBR configuration (B) have their advantages and disadvantages. Side-stream MBRs are considered more energy-intensive, since a powerful pump is required to circulate large volumes of wastewater from the reactor to the membrane module and back. On the other hand, side-stream configuration limits fouling and requires less membrane area due to higher shear and higher cross-flow velocities and higher fluxes, respectively. Due to the membrane being placed outside the reactor, it is easier to operate, can be chemically cleaned in-situ without affecting the bioreactor and the membrane can be replaced quickly, limiting operational downtime [9].

Benefits of the submerged MBRs include the simpler design, ease of sludge discharge and higher energy efficiency. On the downside, submerged MBRs can handle lower concentrations of suspended solids, than side-stream MBRS. The submerged configuration is commonly used for large-scale applications involving low-strength wastewater and is currently dominating the market, while side-stream configuration is more common for small-scale applications and difficult to treat wastewaters [9].

The present study aimed to evaluate the performance of MBR industrial wastewater and conventional wastewater treatment.

METHODOLOGY

Sampling

The industrial wastewater samples collected from the influent and effluent of wastewater treatment plant in Food Industry. The collected samples were submitted to the laboratory, for bench scale treatment (Electrocoagulation treatment) and subsequent analysis (physical, chemical, biological and microbiological analysis) [12].

The industrial wastewater plant employed the bar screen chamber, oil & grease trap, equalization tank, aeration tank, sedimentation tank, then filtration unit.

Material

All material, reagents and standards used in the present study are high quality and American Chemical Society (ACS) vendors which used in analytical laboratories.

Apparatus

Experimental setup

The MBR pilot plant was placed in situ at the municipal wastewater treatment plant of Alexandria and treated the same influent coming to the full sized plant (Sharkyia WWTP).

The system tested was a single tank submerged membrane bioreactor (SMBR) (Figures 1 and 2). The average operational size of the MBR was 2.6 m^3. The membranes used were Kubota microfiltration membranes with a pore size of 0.4 µm, made from chlorinated polyethylene, and with an operating membrane area of about 6.2 m^2. Filtration was continuous and the hydraulic head above the membranes was used to drive filtration, which was regulated by an automatic valve and a flow meter on the permeate line. Air was supplied to the filtration tank as coarse bubbles, for both membrane scouring and biomass maintenance. The retention time (SRT) was 30 days, the average retention time (HRT) was 1.2 days, and the average membrane flux was 18 L $m^{-2}.h^{-1}$.

Analytical Methods

Samples were taken from the plant (influent basin, and effluent), in different periods during 2018/2019, were subjected to analysis of some physic-chemical parameters before and after treatment. Samples of twenty liters in one technique were collected at about 60 cm under water surface. The collected water samples were refrigerated at 4°C for subsequence laboratory tests.

The analysis of wastewater is divided into two groups: the first group was to be carried out immediately once it reaches the lab such as the pH, turbidity, electric conductivity (EC) and dissolved oxygen (DO), and the second group were collected for subsequent trials and analysis in Central Laboratory (total solids "TS", phenol, heavy metals, oil & grease, total nitrogen "TN", total phosphorus "TP", biological oxygen demand "BOD" and chemical oxygen demand "COD" and microbiological examination)[12].

RESULTS & DISCUSSION

In the present study, the industrial wastewater treatment plant of one of Food industry performance was investigated during the period of study. The influent and effluent wastewater of the plant was investigated and comparing with MBR treatment (Bench scale), the wastewater samples were analysed in the laboratory of the plant and the performance of the plant were estimated.

Physical analysis

***pH*:** The influent wastewater pH ranged from 8.1 to 8.3 with average value 8.2 and the standard deviation was 16.6, while the effluent treated wastewater with CT, pH ranged from 7.43 to 7.66 with average value 7.58 and the standard deviation was 17.8, and the pH of MBR treated wastewater ranged from 7.2 to 7.38 with average value 7.33 and standard deviation 9.3. The study shows that the reduction percentage in wastewater pH with CT and MBR treatments were 7.6 and 10.6%, respectively, as shown in Table 1 and Figure 3.

***Conductivity*:** The influent wastewater conductivity ranged from 1204 to 1417 µS/cm with average value 1372 µS/cm and the standard deviation was 41.8, while the effluent treated wastewater conductivity of CT, ranged from 1189 to 1304 µS/cm with average value 1244 µS/cm and the standard deviation was 19.6, and the effluent of MBR treatment ranged from 1198 to 1214 µS/cm with average value 1203 µS/cm and standard deviation was 39.2. The study shows that, the reduction percentages in wastewater conductivity of CT and MBR were 9.3 and 12.3%, respectively, as shown in Table 1 and Figure 3.

***Dissolved oxygen*:** The influent wastewater DO ranged from 0.1 to 0.4 mg/l with average value 0.15 mg/l and the standard deviation was 5.9, while the effluent treated wastewater of CT ranged from 2.6 to 4.8 mg/l with average value 3.9 mg/l and the standard deviation was 54.2. The DO of treated wastewater of EC, ranged from 6.2 to 6.8 mg/l with average value 6.5 mg/l and standard deviation was 14.4. The study shows that the raising percentages in treated wastewater in CT and MBR were 2500 and 4233%, respectively, all DO observation of treated wastewater in the plant didn`t comply with Egyptian regulation (more than or equal 6.0 mg/l) as shown in Table 1 and Figure 3.

Turbidity: The influent wastewater turbidity ranged from 311 to 522 NTU with average value 446 NTU and the standard deviation was 133, while the effluent treated wastewater turbidity of CT, ranged from 86 to 121.2 NTU with average value 97.8 NTU and the standard deviation were 92.1. The turbidity of treated wastewater in MBR, ranged from 4.2 to 8.1 NTU with average value 6.4 NTU and standard deviation was 11.2. The study shows that, the reduction percentages in wastewater turbidity in both CT

Table 1: The Influent & Effluent of CT & MBR quality data and removal percentages (Physical data).

Sample / Parameters	Unit	Influent wastewater			Effluent treated wastewater (CT)				Effluent treated wastewater (MBR)			
		Range	Mean	SD	Range	Mean	SD	Rem. (%)	Range	Mean	SD	Rem. (%)
Temperature	^0C	19.2-27.1	23.4	89.1	19.2-27.3	23.1	98.1	1.3	19.3-26.8	23.2	78.2	0.9
pH	-	8.1 -8.3	8.2	16.6	7.43-7.66	7.58	17.8	7.6	7.2-7.38	7.33	9.3	10.6
Conductivity	µS/cm	1204-1417	1372	41.8	1189-1304	1244	19.6	9.3	1198-1214	1203	39.2	12.3
DO	mg/l	0.1-0.4	0.15	5.9	2.6-4.8	3.9	54.2	-2500.0	6.2-6.8	6.5	14.4	-4233.3
Colour	Hazen	450-700	550	46	165-190	175	43.2	68.2	10-35	15	11.1	97.3
Turbidity	NTU	311-522	446	133	86-121.2	97.8	77.1	78.1	4.2-8.1	6.4	11.2	98.6
TSS	mg/l	255-456	386	139	72-97	87.1	66.3	77.4	3.2-6.5	5.1	13.6	98.7

SD: Standard Deviation; Rem(%): Removal Percentage, CT: Conventional Treatment, MBR: Membrane Bioreactor

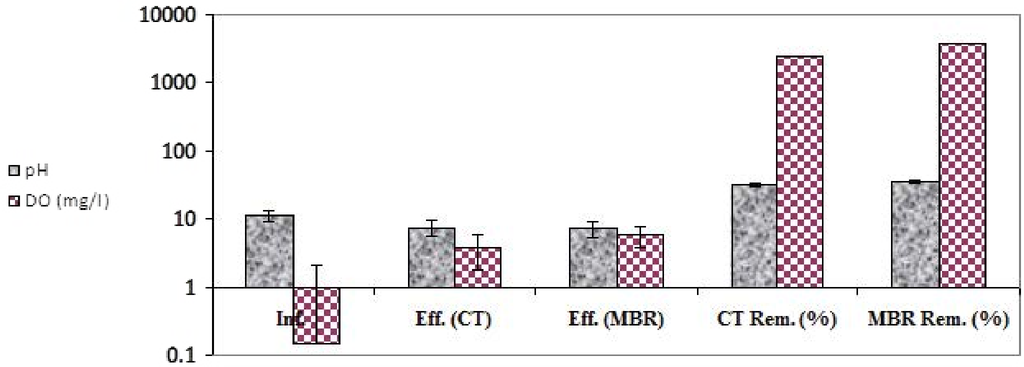

Figure 3: pH & DO removal (%) of CT & MBR.

and MBR were 87.1 and 98.7%, respectively, as shown in Table 1 and Figure 4.

Total Suspended Solids: The influent wastewater TSS ranged from 255 to 456 mg/l with average value 386 mg/l and the standard deviation was 139, while the effluent treated wastewater of CT, ranged from 72 to 97 mg/l with average value 87.1 mg/l and the standard deviation was 66.3. In MBR treatment, the TSS values ranged from 3.2 to 6.5 mg/l with average value 5.1 mg/l and standard deviation 13.6. The study shows that the reduction percentages in wastewater TSS in both CT and MBR were 66.3 and 98.7%, respectively. 12 out of 12 treated wastewater samples in the plant didn`t comply with Egyptian regulation (less than or equal 40.0 mg/l), while all collected samples from MBR treatment were complying with Egyptian regulations, as shown in Table 1 and Figure 4.

The results showed that, the treated wastewater by MBR techniques were complying with Egyptian regulation than in case of treatment by conventional techniques.

Chemical analysis

Chemical oxygen demand: The influent wastewater COD ranged from 544 to 912 mg/l with average value 766 mg/l and the standard deviation was 42, while the effluent treated wastewater of CT ranged from 92 to 142 mg/l with average value 112 mg/l and the standard deviation was 18.8, the COD of treated wastewater using MBR techniques ranged from 14.5 to 27.2 mg/l with average value 18.8 mg/l and standard deviation was 11.1. The study shows that the removal percentages in wastewater of both CT and MBR were 85.4 and 97.5%, respectively. 12 out of 12 treated wastewater samples in the plant didn`t comply with Egyptian regulation (less than or equal 80 mg/l) while all observation in MBR techniques were complying with Egyptian Regulation, as shown in Table 2 and Figure5.

BOD: The influent wastewater BOD ranged from 376 to 682 mg/l with average value 511 mg/l and the standard deviation was 87, while the effluent treated wastewater of CT ranged from 72 to 112 mg/l with average value 96 mg/l and the standard deviation was 33.4, the BOD of treated wastewater using MBR techniques ranged from 9.1 to 12.1 mg/l with average value 10.7 mg/l and standard deviation was 6.6. The study shows that the removal percentages in wastewater of both CT and MBR were 81.2 and 97.9%, respectively. 12 out of 12 treated wastewater samples in the plant didn`t comply with Egyptian regulation (less than or equal 60 mg/l) while all observation in MBR techniques were complying with Egyptian Regulation, as shown in Table 2 and Figure 5.

TN: The influent wastewater TN ranged from 41.2 to 62.1 mg/l with average value 49.2 mg/l and the standard deviation was 42, while the effluent treated wastewater of CT ranged from 11.1 to 29.1 mg/l with average value 19.2 mg/l and the standard deviation was 48.2, the TN of treated wastewater using MBR techniques ranged from 7.2 to 9.6 mg/l with average value 8.4 mg/l and standard deviation was 11.2. The study shows that; the removal percentages in wastewater of both CT and MBR were 61.0 and 82.9%, respectively, as shown in Table 2 and Figure 6.

TP: The influent wastewater TP ranged from 3.6 to 4.8 mg/l with average value 4.2 mg/l and the standard deviation was 23.2, while the effluent treated wastewater of CT ranged from 1.2 to 2.4 mg/l with average value 1.7 mg/l and the standard deviation was 16.2, the TP of treated wastewater using MBR techniques ranged from 0.3 to 0.5 mg/l with average value 0.4 mg/l and standard deviation was 5.8. The study shows that; the removal percentages in wastewater of both CT and MBR were 52.7 and 98.9%, respectively, as shown in Table 2 and Figure 6.

Ammonia: ammonia values of influent wastewater ranged from 27.3 to 34.5 mg/l with average value 31.1 mg/l and the standard deviation was 45.1, while the effluent treated wastewater of CT ranged from 12.1 to 19.4 mg/l with average value 14.4 mg/l and the standard deviation was 19.1, the ammonia of treated wastewater using MBR techniques ranged from 0.3 to 0.4 mg/l with average value 0.34 mg/l and standard deviation was 6.2. The study shows that; the removal percentages in wastewater of both CT and MBR were 52.7 and 98.9%, respectively, as shown in Table 2 and Figure 7. All samples collected from effluent of CT techniques didn`t comply with Egyptian regulation while the collected samples from MBR techniques were complying with the regulation.

Nitrite: Nitrite values of influent wastewater ranged from 3.1 to 6.3 mg/l with average value 4.4 mg/l and the standard deviation was 16.8, while the effluent treated wastewater of CT ranged from 0.9 to 1.7 mg/l with average value 1.3 mg/l and the standard deviation was 34.1, the nitrite of treated wastewater using MBR techniques ranged from 0.06 to 0.1 mg/l with average value 0.08 mg/l and standard deviation was 4.4. The study shows that; the removal percentages in wastewater of both CT and MBR were 70.5 and 98.2%, respectively, as shown in Table 2. All samples collected from effluent of CT techniques didn`t comply with Egyptian regulation while the collected samples from MBR techniques were complying with the regulation.

Nitrate: Nitrate values of influent wastewater ranged from 17.3 to 21.6 mg/l with average value 19.4 mg/l and the standard deviation was 14.2, while the effluent treated wastewater of CT ranged from 9.1 to 12.2 mg/l with average value 10.3 mg/l and the standard

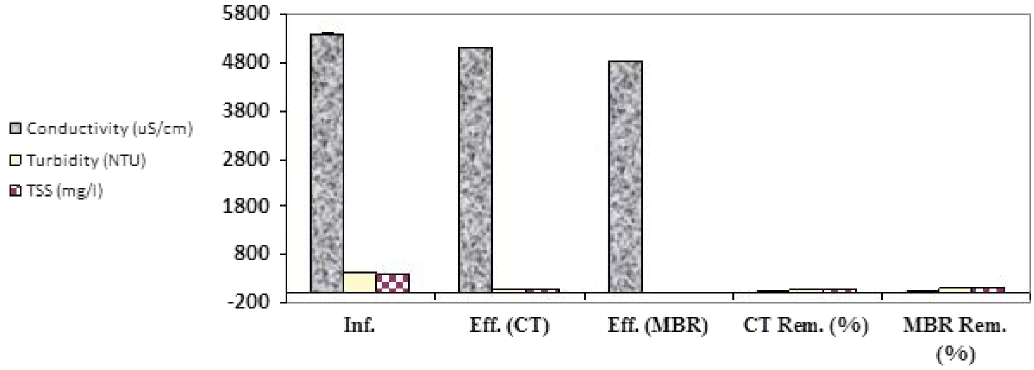

Figure 4: EC, Turbidity and TSS of removal (%) of CT & MBR.

Table 2: The Influent & Effluent of CT & MBR quality data and removal percentages (Chemical data).

Sample / Parameters	Unit	Influent wastewater			Effluent treated wastewater (CT)				Effluent treated wastewater (MBR)			
		Range	Mean	SD	Range	Mean	SD	Rem. (%)	Range	Mean	SD	Rem. (%)
COD	mg/l	544-912	766	42	92-142	112	48.1	85.4	14.5-27.2	18.8	11.1	97.5
BOD	mg/l	376-682	511	87	72-112	96	33.4	81.2	9.1-12.1	10.7	6.6	97.9
TN	mg/l	41.2-62.1	49.2	42	11.1-29.1	19.2	48.2	61.0	7.2-9.6	8.4	11.2	82.9
TP	mg/l	3.9-4.8	4.2	23.2	1.2-2.4	1.7	16.2	59.5	0.3-0.5	0.4	5.8	90.5
Ammonia	mg/l	27.3-34.5	31.1	45.1	12.1-19.4	14.7	19.1	52.7	0.3-0.4	0.34	6.2	98.9
Nitrite	mg/l	3.1-6.3	4.4	16.8	0.9-1.7	1.3	34.1	70.5	0.06-0.1	0.08	4.4	98.2
Nitrate	mg/l	17.3-21.6	19.4	14.2	9.1-12.2	10.3	23.1	46.9	2.2-6.4	3.7	6.9	80.9
Oil & Grease	mg/l	11.1-16.6	12.4	12.2	4.1-6.8	5.4	19.2	82.8	0.3-0.6	0.5	8.4	98.4
Phenol	mg/l	1.1-2.4	1.8	11.8	0.6-1.3	1.1	27.2	38.9	0.1-0.2	0.13	7.1	92.8

SD: Standard Deviation; Rem(%): Removal Percentage, CT: Conventional Treatment, MBR: Membrane Bioreactor

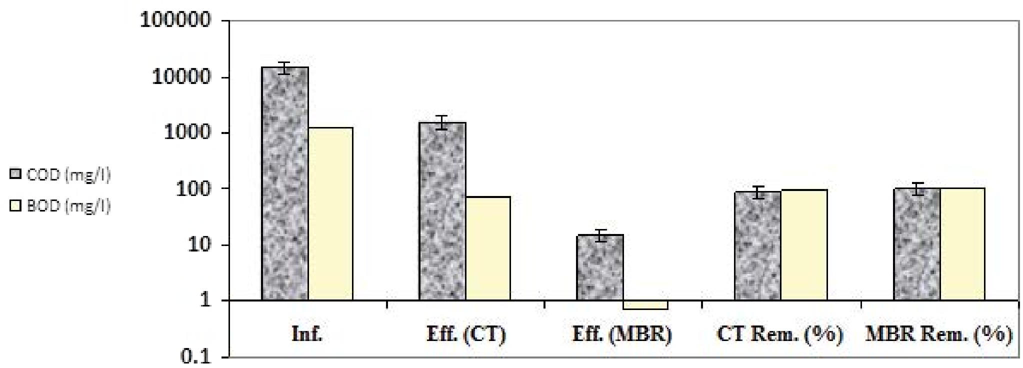

Figure 5: COD & BOD of removal (%) of CT & MBR.

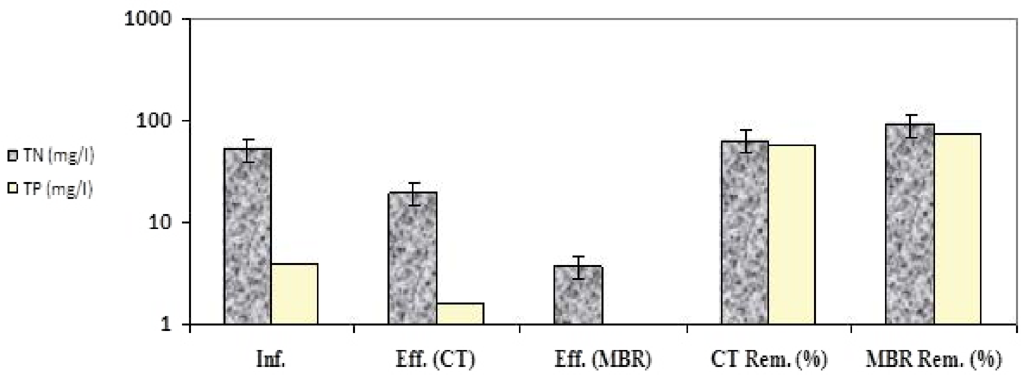

Figure 6: TN & TP of removal (%) of CT & MBR.

deviation was 23.1, the nitrate of treated wastewater using MBR techniques ranged from 2.2 to 6.4 mg/l with average value 3.7 mg/l and standard deviation was 6.9. The study shows that; the removal percentages in wastewater of both CT and MBR were 46.9 and 80.9%, respectively, as shown in Table 2. All samples collected from effluent of CT techniques didn`t comply with Egyptian regulation while the collected samples from MBR techniques were complying with the regulation.

Oil & Grease: OG values of influent wastewater ranged from 11.1 to 16.6 mg/l with average value 12.4 mg/l and the standard deviation was 12.2, while the effluent treated wastewater of CT ranged from 4.1 to 6.8 mg/l with average value 5.4 mg/l and the standard deviation was 19.2, the OG of treated wastewater using MBR techniques ranged from 0.3 to 0.6 mg/l with average value 0.5 mg/l and standard deviation was 8.4. The study shows that; the removal percentages in wastewater of both CT and MBR were 82.8 and 98.4%, respectively, as shown in Table 2 and Figure 6. All samples collected from effluent of CT techniques didn`t comply with Egyptian regulation while the collected samples from MBR techniques were complying with the regulation.

Phenol: phenol values of influent wastewater ranged from 1.1 to 2.4 mg/l with average value 1.8 mg/l and the standard deviation was 11.8, while the effluent treated wastewater of CT ranged from 0.6.1 to 1.3 mg/l with average value 1.1 mg/l and the standard deviation was 27.2, the phenol of treated wastewater using MBR techniques ranged from 0.1 to 0.2 mg/l with average value 0.13mg/l and standard deviation was 7.1. The study shows that; the removal percentages in wastewater of both CT and MBR were 38.9 and 92.8%, respectively, as shown in Table2 and Figure 7. All samples collected from effluent of CT techniques didn`t comply with Egyptian regulation while the collected samples from MBR techniques were complying with the regulation.

The present study showed that; the treatment of industrial wastewater using MBR techniques was efficient than in case of conventional treatment plant, due to the high number of treated wastewater samples didn`t comply with the Egyptian regulation specially with COD, BOD, ammonia, oil & grease and phenols as indicated in Table 2 and Figures 5-8.

Heavy metals analysis

Cd: Cd values of influent wastewater ranged from 0.03 to 0.07 mg/l with average value 0.05 mg/l and the standard deviation was 11.6, while the effluent treated wastewater of CT ranged from 0.01 to 0.04 mg/l with average value 0.02 mg/l and the standard deviation was 6.6, the Cd of treated wastewater using MBR techniques ranged from 0.001 to 0.002 mg/l with average value 0.001 mg/l and standard deviation was 4.2. The study shows that; the removal percentages in wastewater of both CT and MBR were 60.0 and 98.0%, respectively, as shown in Table 3 and Figure 9. All samples collected from effluent of CT techniques didn`t comply with Egyptian regulation while the collected samples from MBR techniques were complying with the regulation.

Pb: Pb values of influent wastewater ranged from 0.03 to 0.07 mg/l with average value 0.05 mg/l and the standard deviation was 12.1, while the effluent treated wastewater of CT ranged from 0.02 to 0.05 mg/l with average value 0.03 mg/l and the standard deviation was 5.1, the Pb of treated wastewater using MBR techniques ranged from 0.001 to 0.004 mg/l with average value 0.002 mg/l and standard deviation was 3.3. The study shows that; the removal percentages in wastewater of both CT and MBR were 25.0 and 95.0%, respectively, as shown in Table 3 and Figure 9. All samples collected from effluent of CT techniques didn`t comply with Egyptian regulation while the collected samples from MBR techniques were complying with the regulation.

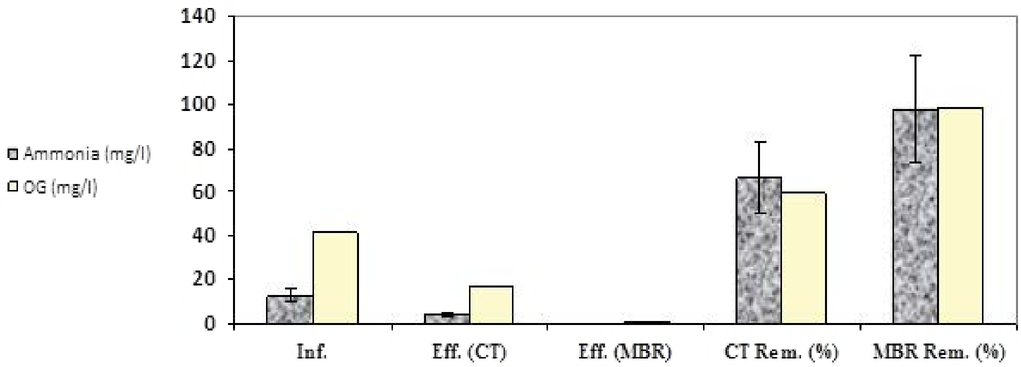

Figure 7: Ammonia and Oil & grease of removal (%) of CT & MBR.

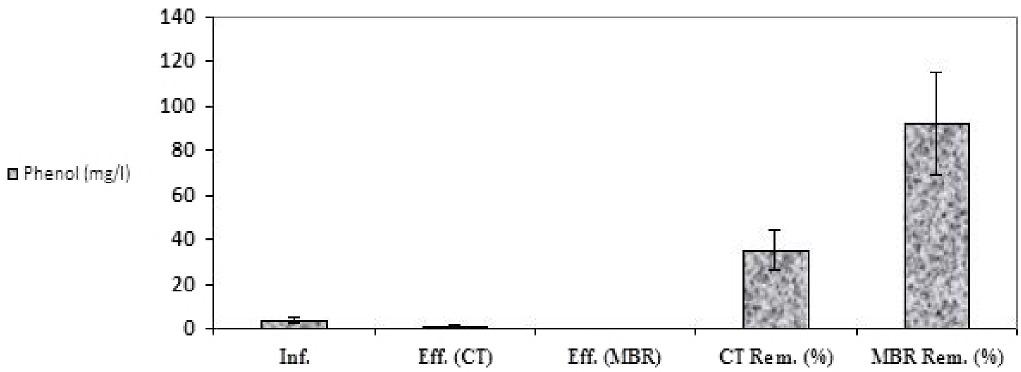

Figure 8: Phenol of removal (%) of CT & EC.

Table 3: Heavy metals data of the influent & effluent of CT & MBR quality and removal percentages.

Sample / Parameters	Unit	Inf.			Effluent treated wastewater (CT)				Effluent treated wastewater (MBR)			
		Range	Mean	SD	Range	Mean	SD	Rem. (%)	Range	Mean	SD	Rem. (%)
Cd	mg/l	0.03-0.07	0.05	11.6	0.01-0.04	0.02	6.6	60.0	0.001-0.002	0.001	4.2	98.0
Pb	mg/l	0.03-0.06	0.04	12.1	0.02-0.05	0.03	5.1	25.0	0.001-0.004	0.002	3.3	95.0
Ni	mg/l	0.32-0.46	0.37	21.1	0.16-0.27	0.21	4.4	43.2	0.001-0.005	0.003	5.5	99.2
Cr	mg/l	0.09-0.12	0.11	16.6	0.04-0.09	0.06	4.3	45.5	0.001-0.002	0.001	6.9	99.1
Zn	mg/l	0.4 – 0.71	0.62	19.2	0.2 -0.52	0.23	19.2	62.9	0.002-0.009	0.004	7.2	99.4
Al	mg/l	0.07-0.18	0.16	16.8	0.04-0.15	0.12	11.4	25.0	0.002-0.007	0.003	4.3	98.1
Se	mg/l	0.081-0.094	0.086	11.2	0.03-0.06	0.04	3.6	53.5	0.001-0.002	0.001	3.2	98.8
As	mg/l	0.012-0.016	0.014	6.2	0.001-0.007	0.004	1.8	71.4	0.001-0.002	0.001	1.8	92.9
B	mg/l	0.14-0.19	0.17	9.2	0.07-0.12	0.09	9.5	47.1	0.003-0.004	0.003	9.1	98.2

SD: Standard Deviation; Rem(%): Removal Percentage, CT: Conventional Treatment, MBR: Membrane Bioreactor

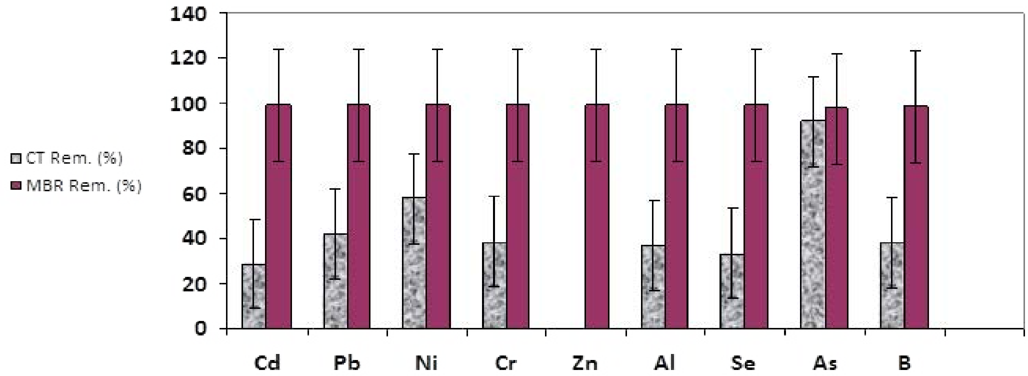

Figure 9: Heavy metals of CT & MBR.

Ni: Ni values of influent wastewater ranged from 0.32 to 0.46 mg/l with average value 0.37 mg/l and the standard deviation was 21.1, while the effluent treated wastewater of CT ranged from 0.16 to 0.27 mg/l with average value 0.21 mg/l and the standard deviation was 4.4, the Ni of treated wastewater using MBR techniques ranged from 0.001 to 0.005 mg/l with average value 0.003 mg/l and standard deviation was 5.5. The study shows that; the removal percentages in wastewater of both CT and MBR were 43.2 and 99.2%, respectively, as shown in Table 3 and Figure 9. All samples collected from effluent of CT techniques didn`t comply with Egyptian regulation while the collected samples from MBR techniques were complying with the regulation.

Cr: Cr values of influent wastewater ranged from 0.09 to 0.12 mg/l with average value 0.11 mg/l and the standard deviation was 16.6, while the effluent treated wastewater of CT ranged from 0.04 to 0.09 mg/l with average value 0.06 mg/l and the standard deviation was 4.3, the Cr of treated wastewater using MBR techniques ranged from 0.001 to 0.002 mg/l with average value 0.001 mg/l and standard deviation was 6.9. The study shows that; the removal percentages in wastewater of both CT and MBR were 45.5 and 99.1%, respectively, as shown in Table 3and Figure 9. All samples collected from effluent of CT techniques didn`t comply with Egyptian regulation while the collected samples from MBR techniques were complying with the regulation.

Zn: Zn values of influent wastewater ranged from 0.4 to 0.71 mg/l with average value 0.62 mg/l and the standard deviation was 19.2, while the effluent treated wastewater of CT ranged from 0.2 to 0.52 mg/l with average value 2.3 mg/l and the standard deviation was 19.2, the Zn of treated wastewater using MBR techniques ranged from 0.002 to 0.009 mg/l with average value 0.004 mg/l and standard deviation was 7.2. The study shows that; the removal percentage in wastewater of both CT and MBR were 62.9 and 99.1%, respectively, as shown in Table 3 and Figure 9. All samples collected from effluent of the both CT and MBR techniques were complying with Egyptian regulation.

Al: Al values of influent wastewater ranged from 0.07 to 0.18 mg/l with average value 0.16 mg/l and the standard deviation was 16.8, while the effluent treated wastewater of CT ranged from 0.04 to 0.15 mg/l with average value 0.12 mg/l and the standard deviation was 11.4, the Al of treated wastewater using MBR techniques ranged from 0.002 to 0.007 mg/l with average value 0.003 mg/l and standard deviation was 4.3. The study shows that; the removal percentages in wastewater of both CT and MBR were 25.0 and 98.1%, respectively, as shown in Table 3 and Figure 9. All samples collected from effluent of the both CT and MBR techniques were complying with Egyptian regulation.

In the same trend the treatment of wastewater with CT was inefficient in removal of Se, As and B metals, while the removal of such metals using MBR was efficient, the percentages reached to 99.2% , as shown in Table 3 and Figure 9.

Microbiological analysis

Total bacterial count: The TBC of influent wastewater ranged from 0.2 x 106 to 0.29 x 106 CFU/ml with average value 0.23 x 106 CFU/ml and the standard deviation was 29, while the TBC of effluent treated wastewater of CT, ranged from 0.06 x 106 to 0.08 x 106 CFU/ml with average value 0.07 x 106 CFU/ml and the standard deviation was 32. The bacterial investigation of treated wastewater using MBR techniques showed that all samples values were nil CFU/ml. The study shows that the removal percentage in wastewater of both CT and MBR were 97.0 and 100%, respectively, and 12 out of 12 treated wastewater samples in the plant didn`t comply with Egyptian regulation (less than or equal 5000 CFU/ml) in case of CT techniques, as shown in Table 4 and Figure 10.

Total coliform: The TC of influent wastewater ranged from 0.1 x 106 to 0.13 x 106 CFU/100ml with average value 0.12 x 106 CFU/100 ml and the standard deviation was 31, while the TC of effluent treated wastewater of CT, ranged from 0.001 x 106 to 0.009 x 106 CFU/100ml with average value 0.005 x 106 CFU/100ml and the standard deviation was 14. The bacterial investigation of treated wastewater using MBR techniques showed that all samples values were nil CFU/100ml. The study shows that the removal percentage in wastewater of both CT and MBR were 95.8 and 100%, respectively, and 12 out of 12 treated wastewater samples in the plant didn`t comply with Egyptian regulation in case of CT techniques, as shown in Table 3 and Figure 10.

Faecal coliform: The FC of influent wastewater ranged from 0.05 × 106 to 0.08 × 106 CFU/100ml with average value 0.066 x 106 CFU/100ml and the standard deviation was 16, while the FC of effluent treated wastewater of CT, ranged from 0.001 × 106 to 0.002 × 106 CFU/100ml with average value 0.001 × 106 CFU/100ml and the standard deviation was 17. The bacterial investigation of treated wastewater using MBR techniques showed that all samples values were nil CFU/100ml. The study shows that the removal percentage in wastewater of both CT and MBR were 98.5 and 100%, respectively, and 12 out of 12 treated wastewater samples in the plant didn`t comply with Egyptian regulation in case of CT techniques, as shown in Table 3 and Figure 10.

FaecalStrepto: The FS of influent wastewater ranged from 0.05 × 106 to 0.08 × 106 CFU/100ml with average value 0.066 x 106 CFU/100ml and the standard deviation was 16, while the FS of effluent treated wastewater of CT, ranged from 0.001 × 106 to 0.002 × 106 CFU/100ml with average value 0.001 × 106 CFU/100ml and the standard deviation was 17. The bacterial investigation of treated wastewater using MBR techniques showed that all samples values were nil CFU/100ml. The study shows that the removal percentage in wastewater of both CT and MBR were 95.8 and 100%, respectively, and 12 out of 12 treated wastewater samples in the plant didn`t comply with Egyptian regulation in case of CT techniques, as shown in Table 3 and Figure 10.

Salmonella: The salmonella of influent wastewater ranged from 19 to 76 CFU/100ml with average value 54 CFU/100ml and the standard deviation was 34, while the salmonella of effluent treated wastewater of CT, ranged from nil to 2 CFU/100ml with average value 1.0 CFU/100ml and the standard deviation was 2.4. The bacterial investigation of treated wastewater using MBR techniques showed that all samples values were nil CFU/100ml. The study shows that the removal percentage in wastewater of both CT and MBR were 98.1 and 100%, respectively, and 11 out of 12 treated wastewater samples in the plant didn`t comply with Egyptian regulation in case of CT techniques, as shown in Table 3 and Figure 10.

The present study showed that, all values of Eff. Treated wastewater using MBR techniques was efficient in removal of bacterial counts while in CT techniques these parameters exceeds the maximum permissible limits in microbiological parameters, and the treated wastewater may be represent a hazardous to the neighbouring environment.

CONCLUSION

The present study summarized the following points of conclusions;

- This research has concluded that the aerobic treatment of wastewater by MBR has a good efficient and best performance as results of the reduction percentages of COD, BOD, TSS, oils and phenol and also a complete elimination of pathogens in MBR effluent treated water.
- The MBR effluent water can be used in different purposes such as irrigation in scarce water area and industrial applications like Middle East countries and also may be due to good treated water quality of the MBR effluent.
- The observation of the present study proves that the effluent of MBR treated water quality can be used in different uses and application.
- The costs of treated wastewater using MBR system is estimated to be 2.8 L.E per cubic meter while the conventional treated wastewater is estimated by 3.6 L.E per cubic meter. The costs include the electricity consumption, labor, maintenance, capital costs and chemicals.

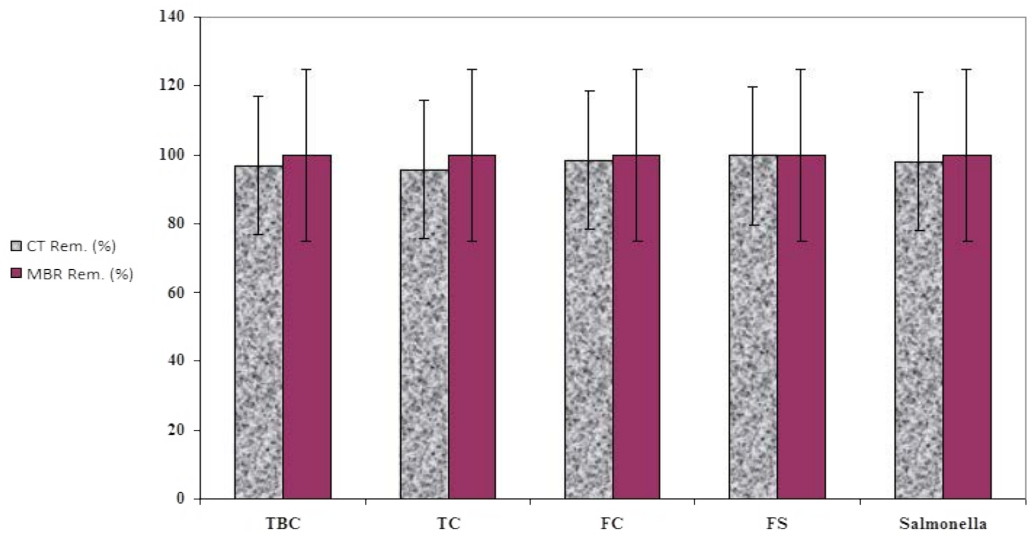

Figure 10: Microbiological of CT & MBR.

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