# Developed Method for Treatment of Industrial Wastewater from Edible Oil Industry using Membrane Technology

**Sarah Elhady, M. Bassyouni, R. A. Mansour, Medhat H. Elzahar, Mamdouh Y. Saleh**

***Abstract: Microorganisms and algae growth on surface water are stimulated in surface water in the presence of effluent wastewater from edible oil industries. This leads to depletion of dissolved oxygen (DO) by eutrophication process result in negative impact on aquatic environment. The new regulation in environment agency and increasing market demand are forcing the industrial sectors to consider finding new solutions and sustainable techniques of the wastewater treatment. In this study, reverse osmosis (RO) membrane filtration has been applied to assess the removal performance of emulsified oil from wastewater. Polysorbate 20 (Tween 20) was used as an oil/water emulsifier. Effect of oil concentrations in terms of chemical oxygen demand (COD) and activated carbon unit on removal efficiency and permeate flux have been studied in details. The results elucidated significant improvement in removal efficiency reached to "98%". The obtained results show promising application of RO membrane (polyamide membrane) at flux "17 L/m2 hr-1". The experiments showed that membrane filtration of wastewater from edible oil is a convenient technique for a possible removal of high concentration of oil (up to 6000 mg/L) with "98%" removal efficiency at permeate flux "17 L/m2 hr-1 "and low fouling rate.***

***Keywords: Edible oil effluent, Reverse osmosis, COD, Removal efficiency.***

## I. INTRODUCTION

The wastewater from edible oil factories mostly produced from the degumming, de-acidification and de-odorization unites [1]. Also blow down of the boiler and washing water that comes from de-oiling of the earth bleaching take part in the effluents in little quantities.

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Until that time, the wastewater discharged direct from edible oil factories into soil and ground water. But, because of the advent of environmental water awareness, the Pollution Control systems have ended up severer and force very tough rules. As well as, Lack of water is other reason for wastewater treatment. For the edible oil wastewater treatment by usual techniques as aerobic or anaerobic breakdown the proportion of BOD to COD would be more than 0.60 [2]. Nevertheless, the wastewater from edible oil factories commonly has its BOD to COD proportion about 0.2 that would lead to damage of micro-organisms beneficial for breaking down. There are many commonly used methods in separation of oil-water treatment. Separation using gravity settling and mechanical techniques are recognized usual methods for treatment, the performance of that based on oil droplets size in effluents. Chemical breaking of emulsion is an active method below suitable usage [3], [4]. Also there were other edible oil separation techniques as air flotation, coagulation [5], [6], and electrocoagulation [7], [8]. On the other hand, these techniques result in massive amount of sludge, difficult procedures, highly energetic and expensive. These drawbacks highlight the necessity for more research using novel separation techniques. Separation using membrane technique has high acceptance through the latest years and becomes an auspicious technique. This technique has numerous benefits as stable permeate characteristic and minor space need. Furthermore no chemical is wanted to be added. Several researches of separation using membrane for treatment edible oil effluents were recorded [9], [10]. Membrane technology showed good performance while used in several wastewater treatment techniques [11], [15]. Reverse osmosis membrane (RO) was used in treatment of varied industrial wastewater [16], [20]. In this paper, the edible oil was separated from effluents by the reverse osmosis (polyamide). Effect of edible oil concentration in feed and effect of pre-treatment on permeate; turbidity and COD rejection efficiency were studied.

## II. EXPERIMENTAL

### A. Materials

- Synthetic edible oil wastewater was setup by mixing 1ml of non-ionic surfactant Tween20 to a 5ml of soybean edible oil and 1L of de-ionized water and mixed for "3.5hr" using electric mixer "300 rpm" at mixing. The mixture had a uniform white color. After preparation the emulsion, it was left to observe its stability.

- Polyamide membrane (PA) in Spiral Wound structure made in USA. Membrane model (TW 30-1812-75), length 26 cm and diameter 5cm, maximum operating temperature "45 oC", maximum operating pressure 150psi and the applied pressure "125psi (8.5bar)",permeate flow rate "12 l/h", pH ranges "2 to 11" maximum feed flow rate "7.6 l/min", salt rejection "98%". RO is the important part of module used to remove dissolved solid, all particles, bacteria and organics.
- Granular activated carbon (GAC) filter column dimension" 6.35 cm x 25.4 cm". The GAC filter clear away main pollutants in water as total organic carbon (TOC), suspended matter (turbidity), volatile organic chemicals (VOC), chlorine, herbicides, organic solvents, insecticides, pesticides, and chemicals resulting in bad tastes, odors, designed for optimal adsorption. The GAC is capable of delivering up to "3.8 liter per minute" of water.
- High pressure pump (model PKM60), Size"2.54 cm x 2.54 cm", Q.max."40 L/min", H.max. "33m", Suct H" 8m"," .37 kw"," .5HP" and" 2850 rpm".

### B. Experimental set-up and operation

The schematic diagram of oily waste water treatment process using RO unit is shown in "Fig. 1". The membrane was washed and saturated by filtered water before using for fifteen minute to make sure that RO reached to the ultimate force. Mixing tank was filled with synthetic–water emulsion, "40L" of wastewater was charged to the process container. The wastewater charged to the RO unit by using high pressure pump. The filtration was started when the power supply was turned on. The wastewater saved with the same pressure through the process "8.5 bar". The oil concentration in effluents was varied in range "3000 mg/l to 6000 mg/l". The treated water comes from RO unit noticed by saving in vessel for "3 min". A total "5.6 l/hr" of permeate collected in each experiment. The permeate and feed samples were examined for COD, O&G and turbidity. After the analysis the treat water contains oil concentration more than the discharge limit and the membrane will be afflicted with fouling through usage. Though, many methods to relieve this problem were endeavored, from them the feed pre-treatment. In the feed pretreatment, adsorption GAC

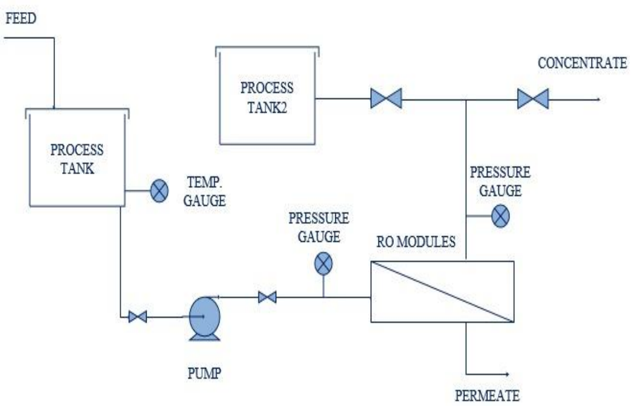


**Fig. 1. The diagram shown in picture of edible oil wastewater treatment process using RO system.**

Usually applied to clear away organic constituents and remaining disinfectants in treated wastewater. In addition, better taste and color. The pretreatment process is very important for clearing high concentration of edible oil in effluents from edible oil factories that would else strictly block the membrane and cause a shorter membrane life. The pretreatment (GAC); for RO membrane is applied to refine the treated water. A simple flow diagram of the system is shown in "Fig. 2". After treatment using this membrane process, the treated water is proper for irrigation and drainage into the sewage network. The analyses for turbidity, COD for all samples were tested to see the efficiency of each process in the reduction of suspended solid and organic matter.

### C. Measurement and analysis

The samples of wastewater and treated water were examined for pH, turbidity, O&G and COD.

- **Chemical oxygen demand (COD)**

Chemical oxygen demand for all samples was measured by COD photometer. Suitable amount of sample "0.2 ml" presented into commercially accessible digested solution (HR-Rang: 200-15000mg/l) consisting of potassium dichromate, sulfuric acid and mercuric sulfate. Then blend was heating for "2 hours" at "150$^0$C" in a COD heater (Hatch Company). After oxidation is ended, the COD concentration was examined using a spectrophotometer.

- **Turbidity**

The samples of permeate were analyzed for turbidity by using turbidity meter (Lovibond meter with NTU).

- **pH (Standard Method)**

The pH measured by using HANNA instruments pHep Hi 96107 Pocket-Sized pH Meter.

- **Oil and grease (Hexane Extraction Gravimetric Method)**

125ml of sample added to "20ml" ethanol and "20ml" sulfuric, shaking well in separation funnel, add "15 ml" petroleum ether, Stand for "15 min" until two layers was separated, collected the above layer that contains the oil (organic layer), Weight Difference between weight of beaker before and after. Then oil concentration calculated as in "equation (1)"

$$oil\ concentration = \frac{wt(mg)}{volume\ of\ sample(ml)x1000} \quad (1)$$

### D. Percent rejection and flux modulus

In Ro membrane unit the separation performance is indicated in terms of %rejection of COD, turbidity and O&G or any other feed factors which calculated in" equation(2)"[3]:

$$R(\%) = \frac{Cf - Cp}{Cf} x100 \quad (2)$$

CP is the concentration of permeate solute while CF is its feed solute concentration.

The water flux ($J^{\omega}$) is the volume of permeate while (V) collected per unit membrane surface area (a) per unit time (t) which calculated in "equation (3)":

$$Jw = \frac{V}{axt} \quad (3)$$

## III. RESULT AND DISCUSSION

### A. Effect of time on permeate flux

The flux observed to decrease slowly at initial time up to around "3 hr" and after 6hr the flux observed constant at constant (pressure of "8.5 bar" and edible oil concentration in synthetic wastewater" 4080mg/l") as shown in "Fig. 3". That is the usual performance of membrane methods. Water flux affected by the occurrences: concentration polarization and membrane blocking outcome from the continuing rise of the surface layer of extremely accumulated pollutants in membrane pores. This is defining the accumulation of membrane-rejected solutes adjacent to the membrane surface. Concentration polarization rises the permeate pressure at membrane surface, which leads to a decrease in water flux. Blocking is a phenomenon leading to decrease of membrane performance because of accumulating of suspended or dissolved matters on outer layer, at its pore openings and because of the gel layer formation over the membrane surface.

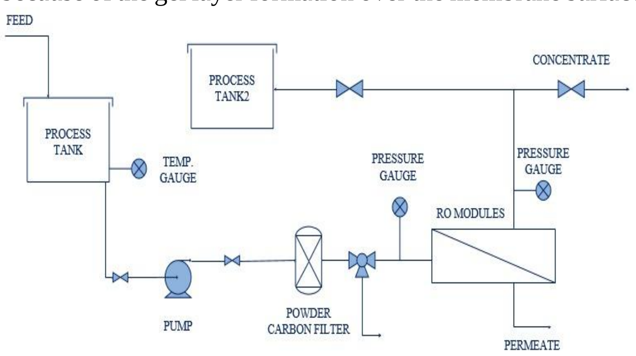


**Fig. 2. The diagram shown in picture of edible oil wastewater treatment unit using a pretreatment.**

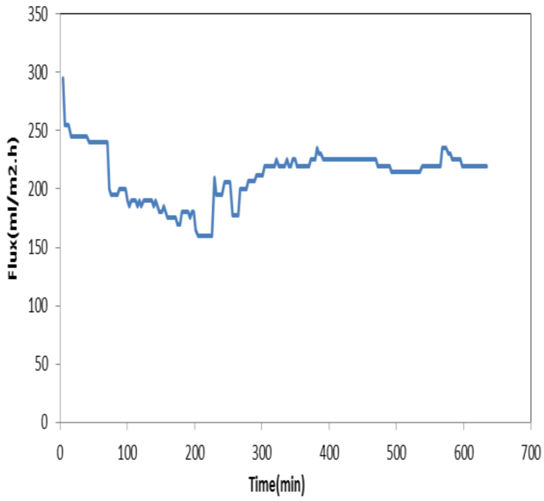


**Fig. 3. Effect of time separation on flux.**

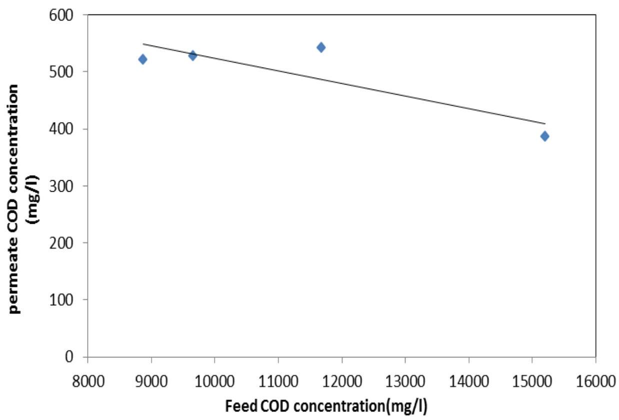


**Fig. 4. Effect of feed concentration on permeate COD.**

**Table- I: Effect of oil concentration in wastewater on treated water properties.**

| Oil effluent concentration (mg/l) | Feed COD concentration (mg/l) | Permeate COD concentration (mg/l) | Rejection efficiency % | Feed turbidity(NTU) | Permeate turbidity(NTU) | Rejection efficiency % |
|---|---|---|---|---|---|---|
| 5653.33 | 15198 | 386 | 97.46 | 875 | 1.28 | 99.8 |
| 4342.92 | 11676 | 542 | 95.35 | 876 | 1.22 | 99.86 |
| 3590.83 | 9654 | 528 | 94.53 | 888 | 1.84 | 99.79 |
| 3298.48 | 8868 | 521 | 94.12 | 890 | 1.6 | 99.82 |

### B. Effect of oil concentration on membrane performance

Effect of oil concentration in wastewater on treated water properties was examined; saving the wastewater at the same pressure "8.5 bar" as listed in "Table- I" this as wastewater from varied oil industries contains high range of suspended solids and oil concentration.

It describes the upper limit of suspended solid in terms of turbidity and COD removal. The results are presented in" Fig. 4"and "Fig. 5" which show that the proportionately with permeate flux decreased increasing feed concentration. The cause of increasing the rejection efficiency and reducing the permeate COD with the increase in oil concentration was because of the formation of bigger droplets. Furthermore, oil droplets settled by the membrane forming a secondary layer on the membrane surface which additional decreasing the size of pore of the membrane. So, removal was improved and permeate concentration was decreased [21]. The average removal of suspended solid in term of turbidity is "99.82%".

The performance of membrane was good COD remained below the permissible levels "<1100ppm" as per Law No. 93 of 1962 for the discharge of wastewater on sewage networks and amended by Ministerial Decree No. 44/20000 but the permeate flux still contains oil and grease concentration "201.6 ppm" more than the permissible 100ppm so the pretreatment is very important.

### C. Effect of pretreatment unit on membrane filtration performance

Membrane fouling results in decrease in the permeate flux values and concentration polarization which produce resistance formation on the membrane surface throughout filtration. After activated carbon pretreatment the load on membrane decrease and the permeate flux increase "3 times" from "5.6 l/hr to 17 l/8hr". As listed in "Table- II" and shown in "Fig. 6". After pretreatment the oil rejection increase to "99.89%" and oil concentration in permeate are all not more than "100 mg/l" which meet the National Discharge Standard of wastewater.

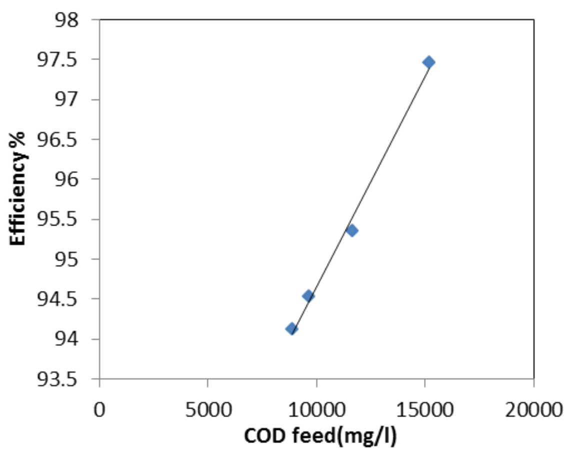


**Fig. 5. Effect of feed concentration on COD rejection.**

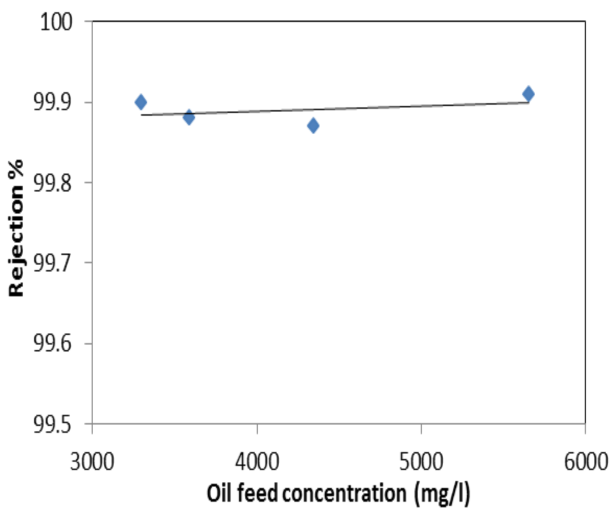


**Fig. 6. Effect of pretreatment on oil rejection.**

**Table- II: Effect of pretreatment on permeate characteristics.**

| Oil conc of feed(mg/l) | Oil conc of permeate before pretreatment (mg/l) | Oil conc of permeate after pretreatment(mg/l) | Rejection% |
|---|---|---|---|
| 5653.33 | 104.78 | 4.8 | 99.91 |
| 4342.92 | 218.9 | 5.3 | 99.87 |
| 3590.83 | 185.5 | 4.3 | 99.88 |
| 3298.48 | 235.4 | 3.2 | 99.90 |

## IV. CONCLUSION

Reverse osmosis polyamide membrane achieved a good result in separation oil produced from edible oil factories in their wastewater. On the other hand, large amount of treated water permeated from RO unit with high removal of turbidity, COD and color without using any heaters in this process. The treated water permeated from RO unit is not acceptable because, it still containing oil concentration more than "100mg/l" and not permissible. So the pretreatment using activated carbon filter before RO membrane to decrease the oil concentration in permeated water and the impurities percentage was permissible under Egyptian programme for anti-pollution specific for industrial wastewater.

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