

**APPLICATION OF MEMBRANE DISTILLATION  
TECHNOLOGY FOR DESALINATION OF THE  
WATER ASSOCIATED WITH THE OIL FIELDS  
PRODUCTION, SIRTE BASIN, LIBYA**

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A Thesis Submitted in Partial Fulfillment  
Of  
The Requirement for the Doctor of Philosophy Degree  
In  
Environmental Sciences

Department of Environmental Basic Sciences  
Institute of Environmental Studies and Research  
Ain Shams University

**2019**

APPROVAL SHEET  
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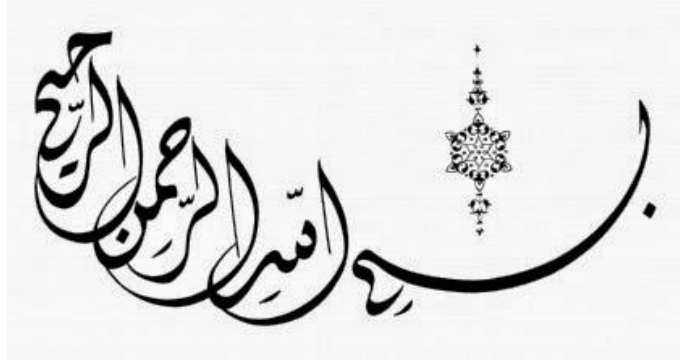
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رَبِّ أَوْزَعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي أَنْعَمْتَ عَلَيَّ

وَعَلَىٰ وَالِدَيَّ وَأَنْ أَعْمَلَ صَالِحًا تَرْضَاهُ

وَأَدْخِلْنِي بِرَحْمَتِكَ فِي عِبَادِكَ الصَّالِحِينَ

سورة الفاتحة

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*Osamah Mohammed Abdulsalam Shahlof.*

# *Dedication*

*To My father & my mother*

*To My family (brothers & sisters)*

*To My uncles (Dr.Abdulhamid shahlol &  
Hassan shahlol)*

*To Mr . Najeeb Alaadly*

I DEDICATED THIS WORK With  
Sincere Thanks And Appreciation

---

*OSAMAH MOHAMED ABDULSALAM SHAHLOL*

## Abstract

Produced water is a very complex mixture and contains different compounds. It has a negative impact on the environment and considers an economic problem associated with oil and gas production. This study has evaluated the characteristics of produced water in Sarir oil field in Libya. The evaluation included physio-chemical parameters e.g. pH, total dissolved solids (TDS), the concentration of both cations and anions constituents. These parameters show a wide variation from well to another in the studied area. Direct contact membrane distillation (DCMD) process was used as one of an advanced techniques in water desalination laboratory unit was used for estimating the performances efficiency of the synthesized nano composite (NC) membranes via 60°C feed synthetic water (NaCl solution) and/or oil field produced water samples with different salinities up to 200,000 mg/L. All synthesized NC membrane produced a high salt rejection of 99.99%. On the other hand, the maximum permeate flux achieved in the order of single wall carbon nanotubes (SWCNTs) (20.91) > Al<sub>2</sub>O<sub>3</sub> (19.92) > CuO (18.92) > multiple wall carbon nanotubes (MWCNTs) (18.20) (L/m<sup>2</sup>.h) with nanomaterial concentration of 0.5, 0.75, 0.75, 0.1 wt.% at concentration of NaCl up to 20,000 ppm, respectively compared with 16% neat polysulfone (PSF) membrane. The optimum operational circumstances were investigated using the feed and permeate temperatures 60°C and 20°C, respectively. Material produced water with salinity 200.000 ppm its permeate flux was 5.97 L/m<sup>2</sup>.h, via polysulfone /polyethylene glycol/single wall carbon nanotubes (PSF/PEG/SWCNTs) membrane with 0.5 wt.% of SWCNTs. Moreover, the membrane indicated sustaining performance stability during operation time 480 min continuous desalination testing, showing that the synthesized PSF/PEG/SWCNTs NC modified membrane may be of magnificent potential to be activated in DCMD procedure for water desalination.

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## **List of Abbreviations**

|                                                            |                      |
|------------------------------------------------------------|----------------------|
| Air Gap Membrane Distillation                              | AGMD                 |
| arabic gum                                                 | AG                   |
| AGOCO                                                      | Arabian Gulf Company |
| Attenuated Total Reflection – Fourier Transform Infra-Red. | ATR-FTIR             |
| Billion barrels                                            | pbbbls               |
| Carbon nanotube                                            | CNT                  |
| chemical oxygen demand                                     | COD                  |
| Desert Research Center                                     | DRC                  |
| Dimethylformamide                                          | DMF                  |
| dodecylamine                                               | DDA                  |
| Dynamic mechanical analysis.                               | DMA                  |
| Electrical Conductivity.                                   | EC                   |
| Electrocoagulation                                         | EC                   |
| equilibrium water content                                  | EWC                  |
| Forward osmosis                                            | FO                   |
| freezing desalination                                      | FD                   |
| Inductive Coupled Plasma.                                  | ICP                  |
| liquid entry pressure                                      | LEP                  |
| Mechanical properties analysis                             | MPA                  |
| Membrane Distillation.                                     | MD                   |
| Microfiltration.                                           | MF                   |
| Multi-effect distillation                                  | MED                  |
| Multistage Flash Evaporation.                              | MSF                  |
| multi-walled carbon nanotubes                              | MWCNTs               |
| nano composite                                             | NC                   |
| Nanofiltration                                             | NF                   |
| nanoparticles                                              | NPs                  |
| oil and gas                                                | O&G                  |
| Part Per Million                                           | ppm                  |
| Polyethersulfone                                           | PES                  |
| Polyethylene Glycol                                        | PEG                  |

## *List of Abbreviations*

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|                                    |                 |
|------------------------------------|-----------------|
| Polysulfone                        | PSF             |
| Polytetrafluoroethylene            | PTFE            |
| Polyvinyl Pyrrolidone              | PVP             |
| Polyvinylidene fluoride            | PVDF            |
| Porosity                           | $\varepsilon$ % |
| prepare polyamide                  | PA              |
| Pure Water Flux                    | PWF             |
| Reverse Osmosis                    | RO              |
| Scanning Electron Microscopy       | SEM             |
| Single-walled carbon nanotubes     | SWCNTs          |
| Sweeping Gas Membrane Distillation | SGMD            |
| Temperature feed                   | $T_f$           |
| Temperature permeate               | $T_p$           |
| Thermo-gravimetric analysis        | TGA             |
| Thin Film Composites               | TFC             |
| Total Dissolved Salts              | TDS             |
| total organic carbon               | TOC             |
| Ultrafiltration                    | UF              |
| Vacuum Membrane Distillation       | VMD             |
| water contact angle                | WCA             |
| water-to-gas                       | WGR             |
| water-to-oil                       | WOR             |
| World Health Organization          | WHO             |
| X-ray diffraction                  | XRD             |