



## Review

## Review of technologies for oil and gas produced water treatment

Fakhru'l-Razi Ahmadun<sup>a,b,\*</sup>, Alireza Pendashteh<sup>a</sup>, Luqman Chuah Abdullah<sup>a</sup>,  
Dayang Radiah Awang Biak<sup>a</sup>, Sayed Siavash Madaeni<sup>c</sup>, Zurina Zainal Abidin<sup>a</sup>

<sup>a</sup> Department of Chemical and Environmental Engineering, Faculty of Engineering, Universiti Putra Malaysia, Malaysia

<sup>b</sup> Prince Khalid Bin Sultan Chair for Water Research Centre, Civil Engineering Department, College of Engineering, King Saud University, P.O. Box 800, Riyadh 11421, Saudi Arabia

<sup>c</sup> Chemical Engineering Department, Razi University, Kermanshah, Iran

## ARTICLE INFO

## Article history:

Received 15 March 2009

Received in revised form 10 May 2009

Accepted 12 May 2009

Available online 19 May 2009

## Keywords:

Oilfield wastewater

Produced water

Oilfield brine

Treatment technology

## ABSTRACT

Produced water is the largest waste stream generated in oil and gas industries. It is a mixture of different organic and inorganic compounds. Due to the increasing volume of waste all over the world in the current decade, the outcome and effect of discharging produced water on the environment has lately become a significant issue of environmental concern. Produced water is conventionally treated through different physical, chemical, and biological methods. In offshore platforms because of space constraints, compact physical and chemical systems are used. However, current technologies cannot remove small-suspended oil particles and dissolved elements. Besides, many chemical treatments, whose initial and/or running cost are high and produce hazardous sludge. In onshore facilities, biological pretreatment of oily wastewater can be a cost-effective and environmental friendly method. As high salt concentration and variations of influent characteristics have direct influence on the turbidity of the effluent, it is appropriate to incorporate a physical treatment, e.g., membrane to refine the final effluent. For these reasons, major research efforts in the future could focus on the optimization of current technologies and use of combined physico-chemical and/or biological treatment of produced water in order to comply with reuse and discharge limits.

© 2009 Elsevier B.V. All rights reserved.

## Contents

1. Introduction .....	531
1.1. Origin of produced water .....	532
1.2. Global onshore and offshore produced water production .....	532
1.3. Factors affecting production volume of produced water .....	532
1.4. Characteristics of produced water .....	533
1.4.1. Dissolved and dispersed oil compounds .....	533
1.4.2. Dissolved formation minerals .....	533
1.4.3. Production chemical components .....	533
1.4.4. Production solids .....	533
1.4.5. Dissolved gases .....	534
1.4.6. Produced water from gas fields .....	534
1.4.7. Produced water from oil fields .....	535
1.5. Fate and impact of produced water discharge .....	535
1.5.1. Salinity .....	535
1.5.2. Dispersed and soluble oil .....	535

**Abbreviations:** BAF, biological aerated filter; BOD, biochemical oxygen demand; Bq/l, becquerel per liter; BTEX, benzene, toluene, ethylbenzene, and xylenes; COD, chemical oxygen demand; CAPEX, capital expenses; FWS, free-water surface; MF, microfiltration; MBR, membrane bioreactor; mg/L, milligram per liter; MWCO, molecular weight cut-off; NF, nanofiltration; O&G, oil and grease; PAHs, polycyclic aromatic hydrocarbons; ppb, parts per billion; ppm, part per million; RO, reverse osmosis; SBR, sequencing batch reactor; SMZ, surfactant-modified zeolite; SS, suspended solids; SSF, subsurface flow; TDS, total dissolved solids; TPH, total petroleum hydrocarbons; UF, ultrafiltration; VSEP, vibration shear enhanced process.

\* Corresponding author at: Department of Chemical and Environmental Engineering, Faculty of Engineering, Universiti Putra Malaysia, Malaysia.

Tel.: +60 3 89466304; fax: +60 3 86567120.

E-mail address: [fakhru@eng.upm.edu.my](mailto:fakhru@eng.upm.edu.my) (A. Fakhru'l-Razi).

1.5.3.	Treating chemicals .....	535
1.5.4.	Heavy metals .....	535
1.5.5.	Radionuclides .....	535
2.	Produced water management .....	535
2.1.	Physical treatment .....	535
2.1.1.	Adsorption of dissolved organics on activated carbon, organoclay, copolymers, zeolite, resins .....	535
2.1.2.	Sand filters .....	537
2.1.3.	Cyclones .....	537
2.1.4.	Evaporation .....	538
2.1.5.	Dissolved air precipitation (DAP) .....	538
2.1.6.	C-TOUR .....	538
2.1.7.	Freeze–thaw/evaporation .....	538
2.1.8.	Electrodialysis (ED) .....	538
2.2.	Chemical treatment .....	538
2.2.1.	Chemical precipitation .....	538
2.2.2.	Chemical oxidation .....	538
2.2.3.	Electrochemical process .....	538
2.2.4.	Photocatalytic treatment .....	538
2.2.5.	Fenton process .....	539
2.2.6.	Treatment with ozone .....	539
2.2.7.	Room temperature ionic liquids .....	539
2.2.8.	Demulsifier .....	539
2.3.	Biological treatment .....	539
2.4.	Membrane treatment .....	540
2.4.1.	Microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO) membranes .....	540
2.4.2.	Bentonite clay and zeolite membrane .....	542
2.4.3.	Combined systems .....	542
2.4.4.	Modified membrane systems to reduce fouling .....	544
3.	Performance evaluation and analysis of treatment technology .....	546
4.	Produced water treatment cost evaluation .....	546
5.	Discussion and future developments .....	546
5.1.	Source of produced water and concentration of pollutants .....	546
5.2.	Final requirements for discharge, recycle or reuse .....	546
6.	Conclusions .....	548
	References .....	548

## 1. Introduction

The significance of oil and natural gas in modern civilization is well known. Nevertheless, like most production activities, oil and gas production processes generate large volumes of liquid waste. Oilfield wastewater or produced water contains various organic and inorganic components. Discharging produced water can pollute surface and underground water and soil.

The permitted oil and grease (O&G) limits for treated produced water discharge offshore in Australia are 30 mg/L (milligram per liter) daily average and 50 mg/L instantaneous [1]. Based on United States Environmental Protection Agency (USEPA) regulations, the daily maximum limit for O&G is 42 mg/L and the monthly average limit is 29 mg/L [2]. As regards the significant matter of environmental concern, many countries have implemented more stringent regulatory standards for discharging produced water. The monthly average limits of O&G discharge and chemical oxygen demand (COD) prescribed by the Peoples Republic of China are 10 and 100 mg/L, respectively [3]. Based on the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention), the annual average limit for discharge of dispersed oil for produced water into the sea is 40 mg/L [4]. On the other hand, because large volumes of produced water are being generated, many countries with oilfields, which are also generally water-stressed countries, are increasingly focusing on efforts to find efficient and cost-effective treatment methods to remove pollutants as a way to supplement their limited fresh water resources. Reuse and recycling of produced water include underground injection to increase oil production, use for irrigation, livestock or

wildlife watering and habitats, and various industrial uses (e.g., dust control, vehicle washing, power plant makeup water, and fire control) [5].

In order to meet environmental regulations as well as reuse and recycling of produced water, many researchers have focused on treating oily saline produced water. Oil content and salinity of produced water from offshore and onshore activities can be reduced through various physical, chemical, and biological methods. In offshore extraction facilities due to space constraints, compact physical and chemical treatment technologies are preferred. However, as capital cost of physical methods and cost of chemicals for chemical treatment of hazardous sludge is high, the application of these methods is limited. Current methods cannot remove minute suspended oil and/or hazardous dissolved organic and inorganic components. On the other hand, biological treatment is a cost-effective method for removing dissolved and suspended compounds from oilfield wastewater in onshore extraction facilities.

The main purpose of this review is:

- To introduce oil and gas produced water origin and characteristics,
- To summarize current technologies available to treat offshore and onshore produced water,
- To focus on combined methods to improve effluent characteristics,
- To discuss advantages and drawbacks of the various treatment methods, and

Download English Version:

<https://daneshyari.com/en/article/581202>

Download Persian Version:

<https://daneshyari.com/article/581202>

[Daneshyari.com](https://daneshyari.com)