

Desalination of produced water from oil production fields by membrane processes

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Abstract

Water co-produced with oil and gas is termed produced water. Produced water is very difficult wastewater to treat and characteristics changes by well to well. In this study, treatability of produced water generated from oil production fields in Trakya region which is operated by National Oil and Natural Gas Company of Turkey was investigated. The aim of this study is to investigate the pre-treatment alternatives of reverse osmosis and nanofiltration membranes and find the most appropriate treatment combination. Management of produced water was also evaluated. Dissolved air floatation (DAF), acid cracking (AC), coagulation (CA) with lime and precipitation, cartridge filters (CDF) (5 and 1 μm), microfiltration (MF) and ultrafiltration (UF) were used as pre-treatment techniques, and nanofiltration (NF) and reverse osmosis (RO) were carried out to reduce salt content of produced water as a final treatment. Different combinations were tried to determine the best pre-treatment combination regarding both the best effluent water quality and high permeate flux. According to the experimental results, treatment combinations provided required treatment to reach discharge standard for COD which is 250 mg/L for petroleum industry in Turkey. However, different treatment combinations should be applied to reach the discharge standard for sodium.

Keywords: Oil production; Produced water; Desalination; Membrane treatment

1. Introduction

Oil is one of the main energy sources of worldwide and its production is a very essential issue. While oil is produced, some unfavourable effects in the environment occur. Produced

water, which is produced during oil production, is one of the most important sources of unfavourable effects. Volume of this wastewater is around 70% of total wastewater produced during oil production [1]. In many instances, this waste stream is seven to eight times greater by volume than oil produced at any given oilfield [2,3]. Produced water is separated from oil or

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gas at the head of the production well. While 65% of this water is re-injected to the well for pressure maintenance, 30% of total is injected to deep well for final disposal in the case of proper aquifer conditions and the rest of the water is discharged to surface water. The water, which is not re-injected to the production well, has to be treated. Feeding groundwater, irrigation and maintaining wetland habitats are the potential options for reuse [4,5]. Additionally, the water re-injected to the well must also be treated due to effects on the reservoir composition. Sometimes an aquifer having appropriate formation conditions cannot be available.

Produced water has distinctive characteristics due to organic and inorganic matters. It includes largely salts and oil hydrocarbons which may be toxic to environment. Produced water is variable and can be very different by well to well. Besides, characteristics of produced water from oil and gas fields can also be very variable.

Many studies have been carried out on produced water from oil fields. Physical and chemical separation processes such as coagulation, acidification and membrane processes have been performed. However, these processes alone did not provide the petroleum waste discharge standards [6]. Successful treatment of produced water generally requires a series of pre-treatment operations to remove different contaminants. Separation techniques that have been tested for the removal of oil, grease, and suspended solids from produced water include walnut shell filtration, fiber ball media filtration, gravity-type cross flow pack separation, ceramic cross flow microfiltration and ultrafiltration [7]. Removal of organic compounds from produced water is carried out by electroflocculation, adsorption, bioreactors, wetlands, ultrafiltration, nanofiltration and reverse osmosis. After appropriate pre-treatment, the high total dissolved solids (TDS) can be removed from produced water by reverse osmosis [7].

There are about 40 oil and gas production wells which produce small amounts of produced water each day in the oil and gas production site (Trakya) which is at the northwest of Turkey. In this site, the portion of the produced water discharged to deep well for final disposal, is coming up to the ground level just after injected to well. This means that deep well injection cannot be a solution for final disposal of produced water in this site. For this reason, this wastewater should be treated before disposal to environment.

It is not possible to design appropriate treatment plant according to literature for produced water because of different characteristics of water. Detailed experimental investigation should be carried out before deciding the final treatment method. The aim of this paper is to compare different treatment methods, especially membrane technologies and determine the best pre- and final treatment systems.

2. Materials and method

2.1. Experimental setup

The experimental system supplied by Osmonics Inc. (Sepa CF lab-scale 316SS membrane cell) was used during membrane experiments. Detailed explanation of experimental set up is given in previous papers [8,9]. Schematic diagram of experimental setup was shown in Fig. 1. The concentrate stream was flowed back to the feed vessel while permeate stream was being collected separately. All experiments were carried out at constant temperature of $25 \pm 1^\circ\text{C}$. Heat exchanger was used as cooling system. Tap water was flowed into thin spiral cooper pipe to keep constant temperature in the feed tank. Firstly, the water was passed from cartridge filter. Then, the water was pumped by high pressure pump to membrane unit. Permeate was collected in a beaker in order to determine the permeate flux.

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