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Review

Review of technologies for oil and gas produced water treatment

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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.

Contents

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, polyaromatic 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.

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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:

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