Comparative Study of Various Treatment Processes of Crude Oil Associated Water Produced from the Upper Assam Basin (India)

TapanJyoti Gogoi, Subrata Borgohain Gogoi, Pranab Boral, and Monem Kallel

Abstract A huge amount of crude oil associated water is produced from the Upper Assam oil field which contains contaminants and is harmful to the environment on direct disposal. From the analysis, we have observed the high presence of turbidity, salinity, Oil and Grease (O&G), Total Suspended Solid (TSS), Total Dissolved Solids (TDS), organic and inorganic constituents. These water samples were not considered safe for disposal according to the rules and regulations provided by the Central Pollution Control Board (CPCB) of India and have to be treated. Initially, they were treated in a sand filter which proves to be cost-effective but the turbidity, O&G, and potassium ion parameters were not within limits. On further treatment in Hollow Fiber Membrane Module setup (HFMS) with microfiltration (MF) and Ultra Filtration (UF) membranes, the previous parameters were brought within range. The decrease in absorbance showed the reduction of contaminants on treatment.

Keywords Produced water · Contaminants · Environment · Organics · Suspended solid

1 Introduction

The crude oil associated water is produced from the subsurface along with crude oil (CO). This water contains contaminants in the form of organic and inorganic constituents along with dissolved and suspended solids. The procedure for producing and processing causes changes in temperature and pressure of oil field water [1]. The addition of treated chemicals, along with the presence of produced gas, oil, and likely solids, would change the properties of the water and its behavior. Understanding the mechanism of water is the key to predict and control many problems related

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M. Ksibi et al. (eds.), *Recent Advances in Environmental Science from the Euro-Mediterranean and Surrounding Regions (2nd Edition)*, Environmental Science and Engineering, https://doi.org/10.1007/978-3-030-51210-1_327

to it. Also, the salt composition is an excellent source of information about the particular reservoir and its depletion process. Water produced with petroleum is growing in importance from an environmental point of view. In the past, the associated water was directly disposed of into the environment without treatment, affecting the biochemical oxygen demand (BOD) of the living organisms in water, but nowadays the government has provided strict rules and regulations for its disposal into the environment as it contains harmful contaminants which may affect plants, humans and living organisms on consumption [1–3].

2 Materials and Methods

Materials: Six samples of CO were taken for analysis along with Calcium chloride, De-oiler, Potassium chloride, Silver chloride, Sodium chloride, Potassium hydroxide, Hydrazine sulfate, Hexamethylenetetramine, Ethanol, Petroleum Ether, Ethylene diamine tetraacetic acid (EDTA), Disodium Salt Dihydrate, Erichrome Black T, Calcium Carbonate, Lithium Carbonate, Hydrochloric Acid, Phenolphthalein, Toluene, Filter paper, sand, sandstone, and charcoal were used.

Methods: The OFPW was separated from crude oil using a separating funnel. The pH, salinity, conductivity, TDS, Turbidity and Dissolved Oxygen (DO) were analyzed in water analyzer. The TSS was measured in the Millipore assembly. The O&G was evaluated in separating funnel using petroleum ether. The Biochemical Oxygen Demand (BOD) was tested in BOD incubator. The Na, Li, Ca and K were determined in flame photometer, while Al, B, P, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Mn, Mg, Ni, Pb, Sr, Te, Zn, Ti were determined in Atomic Absorption Spectrometer (AAS) and Induced Coupled Plasma Optical Emission Spectrometer (ICP-OES). The OFPW was initially treated using a filter of sand, sandstone and charcoal of standard sizes. The membrane treatment was done in Hollow Fiber Membrane Module setup (HFMS) with MF and UF membranes (Figs. 1, 2, 3, 4, 5, 6).

3 Results

3.1 Results of Physical and Chemical Analyses

4 Discussion

The OFPW samples of the Upper Assam Basin were analyzed after a varied process of treatment. Initially, the samples were brown in color with a temperature of 90 °C and turbidity of above 100 NTU which is not safe for disposal into the environment

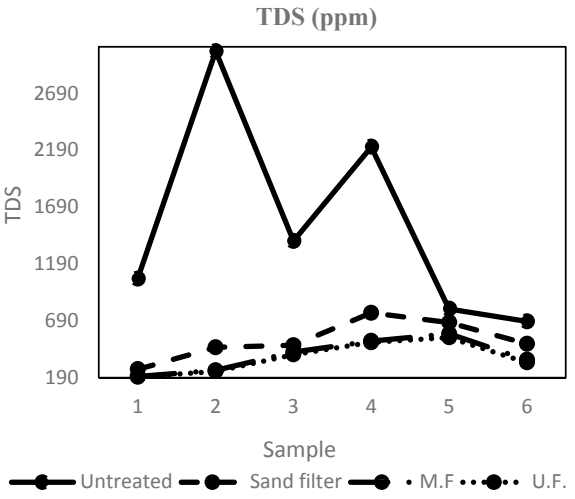

Fig. 1 Graphical representation of Total Dissolved Solid after stages of treatment

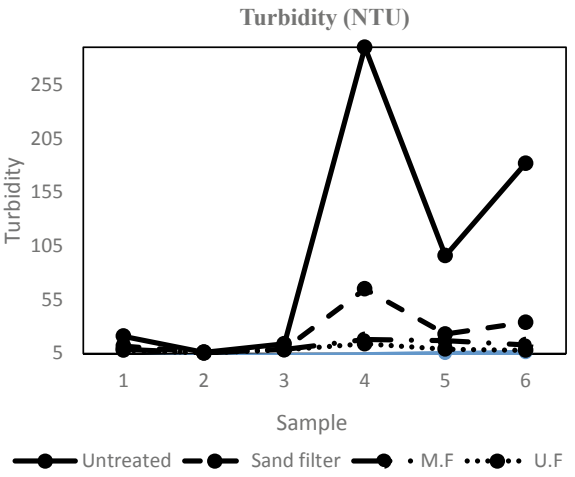

Fig. 2 Graphical representation of Turbidity after stages of treatment

according to the guidelines provided by Central Pollution Control Board (CPCB) of India. Therefore, the following samples were first treated in a filter of sand, sandstone, and charcoal of standard sizes and then in the HFMS with MF and UF membranes for its safe disposal. The pH of the sample is governed by the solubility of carbonates and biocarbonates whereas its salinity is governed by monovalent and divalent ions. The values of TDS and turbidity have to be within limits as they contribute to the presence of dissolved organic solutes and colloidal particles respectively [2, 4]. The TSS determines the presence of suspended solids whose particles are above 2 microns and its removal is governed by Stokes' law. The levels of DO have to increase after treatment as it is essential for the aquatic living organisms to survive. The biological

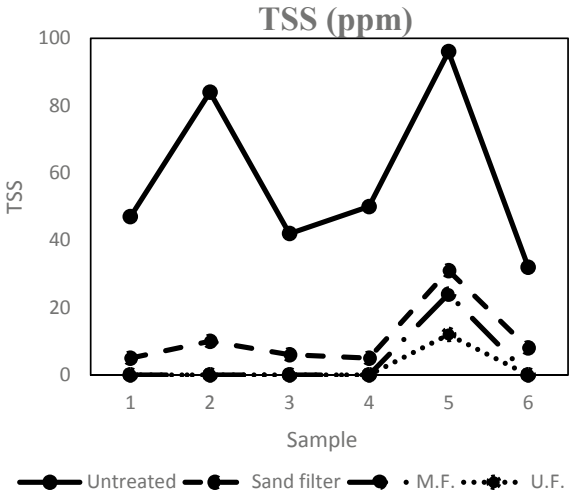

Fig. 3 Graphical representation of Total Suspended Solid after stages of treatment

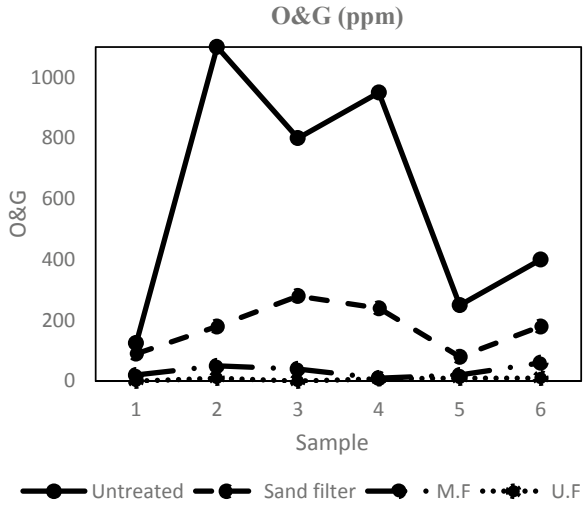

Fig. 4 Graphical representation of Oil & Grease after stages of treatment

toxicity problems and environmental pollution are related to the presence of organics and inorganics in OFPW, whose presence has been lowered with treatment in sand filter and HFMS [1, 5].

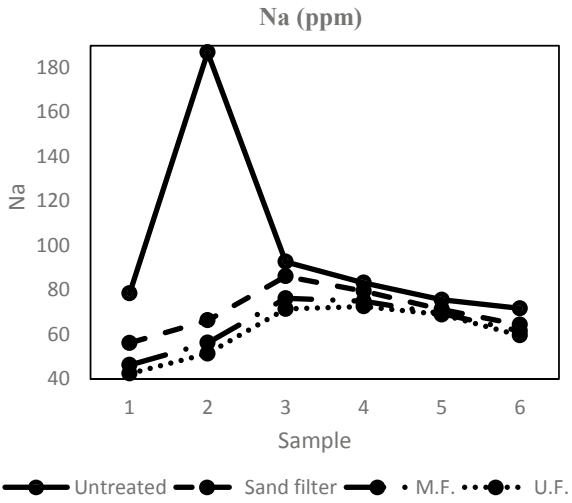

Fig. 5 Graphical representation of Sodium (Na) after stages of treatment

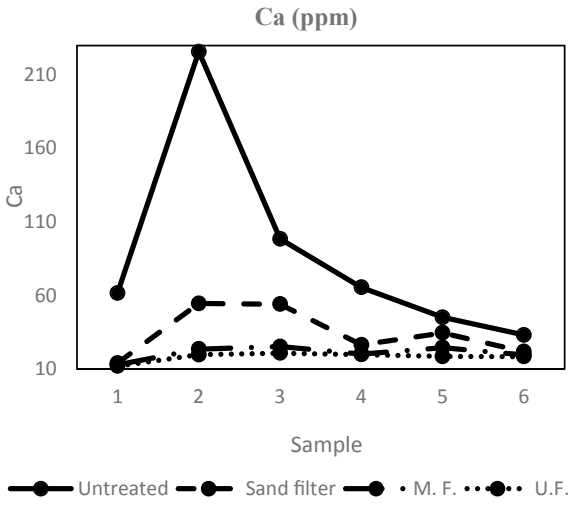

Fig. 6 Graphical representation of Calcium (Ca) after stages of treatment

5 Conclusions

The OFPW contains a complex mixture of both organics and inorganics which has to be treated before disposal into the environment through disposal wells or in secondary recovery pressure maintenance by Water Injection Plants (WIPs). This water contains contaminants which affect the salinity and decrease DO concentration due to the formation of sludge deposits. Also, it may plug and choke the pores at the subsurface of the disposal sites which decreases the effectiveness of various Enhanced Oil Recovery (EOR) techniques [1–3]. The sand filter is highly effective in decreasing

various parameters within specification provided by CPCB of India except turbidity, O&G, and potassium ion. The following three parameters were brought within limits by treating in HFMS with MF and UF membranes. Also, we have observed that the contaminants were absorbed tremendously on the sand filter and on further treatment in HFMS, the contaminants were reduced significantly.

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