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**Softening of Produced Water to be used for  
Alkaline Flooding and Steam Injection in  
Enhanced Oil Recovery (EOR)**

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## ABSTRACT

In oil exploration and production processes, water is produced at the top of the well head together with the hydrocarbons, this water is termed “produced water” and contains different constituents than if not properly treated can harm the natural environment. Furthermore, when an oil field becomes depleted, enhanced oil recovery (EOR) processes need to be applied, these processes inject large amounts of water to the formation in order to help force the oil to the surface and maintain crude oil production at maximum levels.

There are different techniques used for enhanced oil recovery; this project is focussed on alkaline flooding and steam injection. In alkaline flooding, the injection of alkaline chemicals in the reservoir is employed, the reaction of these chemicals with petroleum acids leads to the formation of surfactants that reduce interfacial tension between oil and water and is used in acidic formations. In steam injection, high temperature steam is injected into the reservoir resulting in a reduction of oil viscosity, allowing the oil to flow to the wellbore, this method is commonly used in heavy oil reservoirs.

The aim of this project is to evaluate the efficiencies of various treatment systems to soften all the potential produced water available for recycle (*not all the produced water can be used in its totality, as there are some water losses to evaporation, oil and water separation and water treatment processes, and in the oil recovery method itself*) and re-inject it back to the oil formation as alkaline flooding and steam injection for enhanced oil recovery (EOR). By re-injecting produced water back to the reservoir, environmental impacts can be mitigated since the water constituents/pollutants from produced water can be reduced as well as the water abstraction (water depletion) for EOR practises.

Moreover the outcome and effects of discharging produced water has lately become a significant issue of environmental concern; therefore the environmental impacts of produced water discharges as well as the regulation and legislation in different jurisdictions were described here.

The injection of produced water for EOR is a good way to tackle contamination to surface water and water depletion. In steam injection and alkaline flooding, the removals of salts (expressed as salinity, conductivity, or total dissolved solids [TDS]) in produced water were of paramount importance as they contribute to scale formation within the equipment, precipitate and cause corrosion, resulting in efficiency lost and equipment failure.

Different technologies for the softening of produced water to be used as alkaline flooding and steam injection for EOR were examined. In order to select the best available technology (BAT) for this purpose, parameters such as desired water quality, energy inputs and maintenance and operation (M&O) costs were carefully considered. According to this work, ion exchange (IX) process was way forward to recycle large amounts of produced water and re-inject it back to the reservoir for EOR.