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Components and Treatments of Oilfield Produced Water

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Abstract

In this study, a review of variety of processes that are used in the treatment produced water prior to reuse or to responsible disposal are presented with their environmental issues and economical benefits. Samples of produced water from five locations in Rumaila oilfield/in south of Iraq were taken and analyzed for their contents of brine, some heavy metals, total suspended solids and oil and grease. Moreover, two samples of water were treated using reverse osmosis technique which showed its ability to treat such contaminated water. The results showed that the environmental impact of produced water arises from its chemical composition; i.e., its salt content, its heavy metals, and hydrocarbon contents.

Keywords: *Produced water, environment, heavy metals, components*

1. Introduction

Produced water is water trapped in underground reservoir rocks and is brought to surface along with crude oil and gas. Besides elevated concentration of heavy metals such as barium, uranium, cadmium, chromium, strontium and lead, produced water contains dispersed oil droplets and dissolved organic compounds and significant amount of anion such as carbonate, bromide sulfate. The largest volume of waste in the upstream petroleum industry is produced water. The total volume of produced water in the united states is roughly 21 billion/year [1]. Sources of this water may include flow from above or below or within the hydrocarbon zone, or flow from injected fluids and additives resulting from production activities [2]. Produced water is usually very salty and may contain suspended and dissolved solids, residual hydrocarbons, numerous organic species, heavy metals, naturally occurring radioactive and chemicals used in hydrocarbon extraction [3,4].

The major components of produced water vary according to the type of production activity associated with these types which includes oil production, gas production and coal bed methan (CBM) production. For example, produced waters from gas production are relatively more toxic than produced waters from oil production due to the higher contents of flow molecular – weight aromatic hydrocarbons such as benzene, toluene, and xylene [5,6].

Untreated produced water causes number of problems; these problems are:

- Excess sodicity which cause clay deflection.
- Excess soluble salts which can cause plants to dehydrate and die.
- Reduced oxygen level enough to damage aquatic species [2].
- Injection formation plugging due to suspended solids, which results in injection pressure increase and decrease in the produced water injection flow rate.
- Scale problem which causes well bore clogging and fluid flow prevention [7,8,9].
- Environmental impact due to chemical additive like corrosion inhibitor and H_2S scavenger [10].

A large number of methods were used as treatment technologies [11-21] such as heat treating, gas flotation, chemical separation, filtration, and biological degradation. Many methods are available to remove the dissolved hydrocarbons such as adsorption, volatilization, oxidation, ultraviolet, irradiation, precipitation, and biological processes [22,23,24]. Several methods are available to remove the suspended solids (like cuttings, sand and clay particles) and there methods are filtration, coagulation, gravity separation, and biological treatment [25,26,27,28].

The dissolved solids which include salt, hardness ions and heavy metals can be treated by processes like ion exchange, precipitation, evaporation, distillation and bio treatment [22,29,30,31].

Table (1) summarizes the reviewing of different technologies according to their environmental and cost issues.

Table 1,
Different Produced Water Treatment Technologies with Their Cost and Environmental Issues.

Treatment Method	Cost	Environ-mental Effect
Biological Treatment	Low operating costs	None- very low
Gravity Separation		
1. Plate Separators	Low operating costs	Very low
2. Hydrocyclones	Low operating costs	Very low
3. Decanting centrifuge	Low operating costs	Very low
Gas Flotation + Gravity Separation + Chemical Addition	Moderate operating costs	Low
Membrane Filtration (Microfiltration, Nanofiltration and Reverse Osmosis	Low operating costs	Low
Carbon Adsorption	Moderate operating costs	Moderate
Air stripping	Low operating costs	Moderate
Ultra-Violet Light	Low operating costs	Moderate
Chemical Oxidation (Ozone and/or hydrogen peroxide oxidation)	Moderate operating costs	Moderate
Precipitation	Low operating costs	Moderate
(Flocculating Polymers, biocides, reverse emulsion breakers, and corrosion inhibitors)	High costs	Moderate - High

2. Experimental Work

Samples of produced water from five locations at Rumaila oilfield (south of Iraq) were collected and analyzed chemically for their brine composition and concentration of some heavy metals. Also the parameters such as Tss oil and grease, and PH are measured. More over, two samples of contaminated water were treated using micro filtration and reverse osmosis membranes. The analysis and treatment were done at Al-Mansour state company.

Experimental apparatus
Reverse Osmosis

Reverse osmosis (commonly abbreviated as R.O) is a physical process which allows dissolved salts to be removed by forcing water to pass through a semi permeable membrane. The permeate, or product water passes through the membrane, while the dissolved salts, particles and the organic matter which are unable to pass through the membrane are conveyed to the drain as a concentrate or rejected water. The heart f an R.O declinator is the osmotic membrane. The R.O systems use spiral wound aromatic polyamide membranes capable to treat the salinity of seawater as TDS. The Concentration materials used, particularly for the parts in contact with the water, have proven resistance to corrosion (stainless steel, PVC and poly ethylene). R.O. units are fitted with an automatic system for control of the influent and effluent water pressure and of motor absorption and also equipped with flow meters and conductivity meters. The operation data are 380V, 50Hz, three phase flow rate 300 to 6000 L/hr(liter/hour).

Microfiltration

Filtration is a physical process used to reduce turbidity. The impurities trapped by the filtering cartridge are removed by a backwashing procedure powered by an impeller with calibrated holes installed inside the stainless steel cartridge which is able to spray jets of water across the entire surface of the cartridge and propel the trapped deposits to the drain.

The materials used for construction are non toxic and of high quality; these filters allow a degree of filtration of 100 microns to 300 and are able to work at an operation pressure of 10 bar.

PH-meter

The specifications of an electric meter modelS 595-PH are:

- Standard measuring range 0-14 PH.
- Indicator: digital, liquid crystal (LCD), 3 1/2 digit, h = 1/2".
- Current output 4-20 mA DC on load < 700 ohm.

3. Field Observations

It is important to mention that according to field investigations in the oilfield under study, procedure water coming from oil wells is four to seven times the volume of oil produced. These volumes represent huge amount of contaminated water that require economical and environmentally friendly methods of treatment to be reused or disposed off safely. Also, there are about tens of wells that have been used as disposal wells for produced water after a restricted water treatment.

Discharging processes were done in Al-Dammam formations which have very low pressure property. Although this disposal option was not desirable due to many environmental concepts, the injection continued until the disposal wells were in capable of receiving more water.

4. Results and Discussion

The water analysis of Rumaila oilfield is summarized in table (2).

Although, the waters were taken from five locations, no significant differences are shown in the results since they related to the same oilfield. As known, the properties or constituents of produced water vary according to geological formation, to the type of hydrocarbon being produced and to the enhanced operations which are conducted. It can be seen in higher concentrations of solids, heavy metals like barium, strontium, calcium and bicarbonate ions have the potential to precipitate as scale.

Table 2,
Constituents of Produced Water at Five Locations of Rumaila Oilfield.

Constituent	Produced Water (mg/L)				
	Location 1	Location 2	Location 3	Location 4	Location 5
Sodium	35000	25000	28000	19700	22000
Potassium	720	450	410	250	220
Magnesium	390	810	670	520	480
Barium	280	190	180	220	200
Strontium	720	580	630	590	500
Sulfate	80	100	190	110	130
Chloride	65000	66000	67100	62000	61000
Calcium	5500	4400	4100	4000	4700
Cadmium	30	25	26	29	21
Chromium	110	90	95	90	100
Copper	100	85	90	75	95
Lead	280	210	220	160	150
Nickel	190	170	180	130	140
Zinc	150	88	99	110	120
HCO_3	650	600	610	700	630
PH	8.2	8.5	8.6	8.4	8.1
TSS	8000	7500	8100	7600	7900
Oil and Grease	600	650	670	640	710

The scale can clog flow lines from oily sludge's that must be removed and form emulsion that are difficult to break [9]. However, the high concentrations of some heavy metals can cause many production problems for example the presence of different charge ions such as barium and sulfated calcium and sulfates iron and oxygen can cause deposits at discharge sites. Table (3) shows typical concentrations of pollutants in two treated produced water samples.

These data represent good results that have been achieved with this available technology by reverse osmosis membranes.

Table 3,
Results Using Reverse Osmosis And Micro Filtration.

Constituent	Untreated (mg/L)	Untreated (mg/L)	Treated (mg/L)
Sodium	35000	28000	100
Potassium	720	410	10
Magnesium	390	670	ND
Barium	280	180	10
Strontium	720	630	15
Sulfate	80	190	ND
Chloride	65000	67100	150
Calcium	5500	4100	70
Cadmium	30	26	ND
Chromium	110	95	ND
Copper	100	90	ND
Lead	280	220	15
Nickel	190	180	ND
Zinc	150	99	ND
HCO_3	650	610	10
PH	8.2	8.6	7.4
TSS	8000	8100	350
Oil and Grease	600	670	10

The obtained water quality is suitable for many different usages such as re-injection processes for enhanced oil recovery or irrigation and other human purposes. In the present treatment system, the removal efficiency can be enhanced with an increase in the treatment stages which depend on the required water quality. Precipitation was detected at a number of micro filters and membranes which can be attributed to presence of oil, grease and lead contents in water respectively. It was necessary to remove these precipitations by chemical washing for example.

5. Conclusions

- Field observations confirmed that produced water is responsible for many problems like corrosion, scale, microbial growth and dirty equipment.
- Practices such as discharge to surrounding, storage on the surface in open tanks, re-using with a restricted treatment can arise many oilfield problems.
- Chemical analysis of the produced water from other drilling locations is required to cover the wide range differences in the chemical and physical properties of water.

Notation

CBM	Coal Bed Methan
BTEX	Benzene-Toluene-Ethyl benzene-xylene
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
H_2S	Hydrogen Sulfide
PAHs	Polycyclic Aromatic Hydrocarbons

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مكونات ومعالجات الماء المنتج من الحقول النفطية

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الخلاصة

في هذه الدراسة تم عرض مراجعة لمختلف الطرق المستخدمة في معالجة الماء المنتج والتي تسبق اعادة الاستخدام او التخلص المسؤول مع اعتباراتها البيئية وفوائدها الاقتصادية .

تم اخذ نماذج من خمسة مواقع في حقل الرميله/جنوب العراق وحللت لمحتواها من الاملاح وبعض العناصر الثقيله و المواد الصلبه العالقه والنفط والدهون.اضافة الى ذلك نموذجين من الماء تم معالجتها باستخدام تقنية التنافذ العكسي والتي اظهرت قابلية هذه الطريقه في معالجة هكذا ماء ملوث.

أظهرت النتائج ان التأ ثير البيئي من الماء المنتج يكون من تركيبه الكيميائي ،أي بمعنى أخر محتواه من الاملاح ومن العناصر الثقيلة ومن الهايدرو كاربونات .