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Waste Water Production Treatment Method and Facilities available in Oil and Gas industry

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Abstract _ in this study, a review analysis of variety of processes that are used in the treatment and management produced water prior to reuse for petroleum operation (Hydraulic Fracturing and Injection) was measured. Samples of produced water from two locations in Heglig oilfield/in western of Sudan were taken and analyzed for their contents, some heavy metals, total suspended solids (TDS), total dissolved solid (TSS) and oil and grease. Moreover, two samples of water were tested biologically to detect the presence sulfate reducing bacteria (SRB) that are most common found in water associated with petroleum.

Keywords_ Produced water, Heavy metals, SRB and Components

1. Introduction

Produced water is the natural water or formation water is always found together with petroleum in reservoirs [1]. Other definition "Produced water" is water trapped during subsurface formations which is brought to the surface along with oil or gas [2].

Sometime called "flowback water" if It brought from fluid injected in to the well or reservoir at high pressure as part of a hydraulic fracturing (frac) operation [3]. It is slightly acidic and sits below the hydrocarbons in porous reservoir media Extraction of oil and gas leads to a reduction in reservoir pressure, and additional water is usually injected into the reservoir water layer to maintain hydraulic pressure and enhance oil recovery. This water is known as produced water or oilfield brine, accounting for the largest volume of byproduct generated during oil and gas recovery operation [4], [5].

Produced water has a complex composition, but its constituents can be broadly classified into organic and inorganic compounds [5], [2]. Including dissolved and dispersed oils, grease, heavy metals, radionuclides, treating chemicals, formation solids, salts, dissolved gases, scale products, waxes, microorganisms and dissolved oxygen6 [6],[7],[5]. And it contains dissolved formation minerals, production chemicals, dissolved gases (including CO2 and H2S) and produced solids [8]. It has a huge variation in the level of the organic and inorganic composition and that is depends on geological formation, lifetime of the reservoir and the type of hydrocarbon produced.

Dispersed and dissolved oil components are a mixture of hydrocarbons including BTEX (benzene, toluene, ethyl benzene and xylene), PAHs (polyaromatic hydrocarbons) and phenols. Dissolved inorganic compounds or minerals are usually high in concentration, and classified as cations and anions, naturally occurring radioactive materials and heavy metals [9]. Cations and anions play a significant role in the chemistry of produced water [10].

Produced solids include clays, precipitated solids, waxes, bacteria, carbonates, sand and silt, corrosion and scale products, proppant, formation solids and other suspended solids [7].Their concentrations vary from one platform to another. Produced solids could cause serious problems during oil production. For example, common scales and bacterial can clog flow lines, form oily sludge and emulsions which must be removed [11].

Produced waters are reused for injection in the purpose of enhanced recovery or disposal, for instance in the United States the amount of water production for each barrel (bbl) of oil produced, an average of 10 bbl of water is produced for an annual total of about 3 billion tons.

Globally, _250 million barrels of water are produced daily from both oil and gas fields and more than 40% of this is discharged into the environment. Currently, oil and gas operators treat produced water via one or more of the following options [2].

- Avoid production of water: water fractures are blocked polymer gel or downhole water separators, but this option is not always possible.
- Inject into formations: produced water may be injected back to its formation or into other formations. This option often requires transportation of water, and treatment to reduce fouling and bacterial growth. In the long term, the stored produced water may pollute the underground waters.
- Discharge to the environment: produced water may be discharged to the environment as long as it meets onshore and offshore discharge regulations.
- Reuse in petroleum industry operations: minimally treated produced water may be used for drilling and workover operations within the petroleum industry.
- Apply in beneficial uses: produced water may be consumed for irrigation, wildlife consumption and habitat, industrial water and even drinking water. However, beneficial uses of produced water may involve significant treatment [2], [7].

For Heglig Oilfield, as case study the amount of water production or water cut reach to 95% from total hydrocarbon fluids, making oil production is non-economic. Several studies conducted in the field of Heglig for treating and management of produced water, most of treated water reused for irrigation. No method was presented recently for reusing produced water in oil operation. Therefore, the objective of this paper is to remove metals from produced water in the purpose of reuse these water for reinjection process for enhanced recovery. So the most metals effect and selected such are (Fe^{++}, Ca^{++}, and Mg^{++}). These metals represent the most common scales oil field plus Barium and strontium [12].

Scale deposition is one of the most important and serious problems that inflict oil field water injection systems. Scale limits and sometimes blocks oil and gas production by plugging the oil-producing formation matrix or fractures and perforated intervals. It can also plug production lines and equipment and impair fluid flow.

In case of water injection systems, scale could plug the pores of the formation and results in injectivity decline with time [13], [14], [15], [16].

2. Experimental Work

2.1 Sample collection

Samples of produced water from two locations at Heglig oilfield (western of Sudan) were collected and analyzed chemically, physical and biologically for their composition and concentration of some heavy metals cations and anions. Also the parameters such as TSS, TDS, electrical conductivity, oil and grease, and PH are measured using standard methods. Moreover, samples of contaminated water were treated using sodium chloride for bacteria. The analysis and treatment were done at Petroleum Laboratories, Research &Studies, Sudan University of Science and Technology and Germany (Rheine Waal University for applied science).

2.2 Batch study

2.2.1 Oil & grease measurement

Oil and grease is extracted by APHA standard methods. .A measured volume of the sample (250 ml=V) was introduced into separating funnel with 1.5ml of HCL1:1 was added. 7.5ml of n-Hexane was added to the acidified sample and shake for 2min. when it reaches the equilibrium the organic

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layer of Oil &Hexane was separated in evaporating dish. Then replicated this step 2 times more and talk all separated all separated organic layer then transferred into a pre-weighed (W1(gm))flask and hexane is evaporated in a water bath at 103 to 105°C for 1h .The flask is reweighed (W2 (gm)) and the Oil & grease content is Calculated in ppm (mg/l) as:

$$\text{Oil \& grease (mg/l)} = \frac{a-b}{\text{ml sample}} * 10^6$$

2.2.2 Total Suspended Solids measurement (TSS)

Solids analyses are important in the control of biological and physical wastewater treatment processes and for accessing compliance with regulatory agency wastewater effluent limitations. A volume of produced water measured according to APHA standard methods carefully removed filter from filtration apparatus was done and transfer to an aluminum weighing dish in order to reduced high dissolved solids then Dried for at least 1h at 103 to 105ºC in an oven, cooled in desiccator to balance temperature and weigh and the TSS content is Calculated in ppm (mg/l) as:

$$\text{Total suspended solids mg/L} = \frac{(a-b)*1000}{\text{Sample volume ml}}$$

2.2.3 Total Dissolved Solids (TDS)

Total dissolved solids and electric conductivity were measure using Conductivity meter (Jenway 4320). A measure volume of the samples (50 ml for tow sample) were introduced in the instrument.

The results should be achieved directly; TDS content is calculated in ppm (mg/l) and conductivity in (µs) in the table (1).

2.2.4 Metals Test

Cations (Na, K, and Ca) measured using PFP7 Flame Photometer (Jenway), And ICP (Ionic couple plasma) for heavy metals.

3. Bacteria Problems and Identification

Bacterial introduction into an injection well can occur during drilling and `completion/stimulation/workover operations, as well as during long term injection operations [17]. Anaerobic bacteria notably sulfate reducing bacteria (SRB), generally tend to be the most problematic in oilfield situations, but, in some injection operations, if sufficient dissolved oxygen is present in the injection fluids, aerobic bacteria activity may also be an issue [18]. Many organisms are fond in the produced water and in all water e.g. bacteria, algae fungi and protozoa, most problems associated with oil industry are caused by one group of organism in particular Sulfate Reducing Bacteria [19],[20].

Hydrocarbon-utilizing bacteria in produced water were obtained by plating out low dilutions (10^{-1} to 10^{-9}) of samples onto modified Nutrient agar medium [16]. The medium has been used the following, MacConkey broth for identification and Sub culture with nutrient agar with different Media with different concentrations used, (KIA (kliger, iron agar)), Peptone water, Citrate medium, Urea medium), to detect the presence of SRB indicated by H2s production. Produced water (instead of distilled water). The medium was autoclaved for 15 min and incubated at 35 0C to 37 0C for 24hr, 48hr. After incubation, the results of whole tests in table (2).

Regarding eliminated the presence of bacteria, two bottles of bacterial media (nutrient broth) used, one of them was inoculated. And added sodium chloride with 75g/l concentration to another, after that then inoculated using Monica standard [17], [21], [22]. Both inoculates incubated at 35c to 37c for 24hr. the results showed that growth on

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one bottle which without additive saline, but there is no growth in the other bottle which has more salinity. PH measured for the peptone medium with and without additives (Nacl).

4. RESULTS

Physical and chemical compositions of produced water summarized in table (1).

Table (1) Composition of produced water (Raw & treated)

Compounds (mg/L)	First pond from Heglig field (raw water)	Last pond from Heglig field (treated water)
pH-value	8.9 –9.5	8.3-8.6
Oil and grease(mgl/L)	250-300	30-50
TDS(mg/l)	1002	1217
Conductivity (µmhos/cm)	1.669	2.03
Total Suspended Solids (mg/L)	982	378
Anions		
Chloride (mg/L as Cl-)	3.9	0.99
Cations		
Sodium (mg/L as Na1+)	575	678
Potassium (mg/L as K1+)	12.77	14.03
Calcium (mg/L as Ca2+)	7.193	8.190
Heavy metals(ppm)		
Al(Aluminum)	21.16	0.2891
Cadmium (Cd) mg/l	<0.0009	<0.0009
Chromium(Cr)	0.0158	<0.0013
Copper mg/l (Cu)	0.0249	0.0249
Cobalt(Co)	<0.0013	<0.0013
Iron mg/l (Fe)	12.17	12.17
Lead (Pb) mg/l	<0.0150	<0.0150
Manganese (Mn) mg/l	0.1052	0.0049
Nickel (Ni) mg/l	0.0155	0.0127
Zinc (Zn) mg/l	0.0660	0.0474
Boron (ml/L) (Br)	0.01	0.01
Mercury (Hg)mg/l	ND	ND
Phosphorus mg/l	<0.001	ND
Cadmium (Cd) mg/l	ND	ND

Table (2) Biochemical Tests

Test/result	KIA	Urea	Cit	Ind
Positive	Butt: yellow Slope: yellow	Pink color	Blue color	Red ring
Negative	Butt : red Slope : red	Colorless	Green color	Yellow ring

Table (3) pH. For media

Peptone water	PH	Temperature
Sample with Nacl	6.04	21.6 C^0
Sample without Nacl	6.4	18.6 C^0

5. Conclusion & Recommendation

1. This study was conducted to determine the physical and chemical properties of produced water to determine the degree of usability for re-use in the oil fields operation.

2. This water needs further treatment to become suitable for use in injection operations according to environmental protection agency (EPI).
3. Some previous studies of this field is confirmed that this can be fresh water Compared to FAO standards for unrestricted irrigation water. However, need further treatment to heavy metals (Fe+2) and some metals (Ca+2and Mg+2).
4. Available technologies of produced water treatment and management need to be optimized and new technique.
5. Regarding to SRB organism, need their own laboratory in field site because the central field far from the central laboratory until you confirm the presence of SRB into produced water in the so to take suitable additions necessary when re-used.

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Fig.1. After treatment macConkoy broth after 24hr

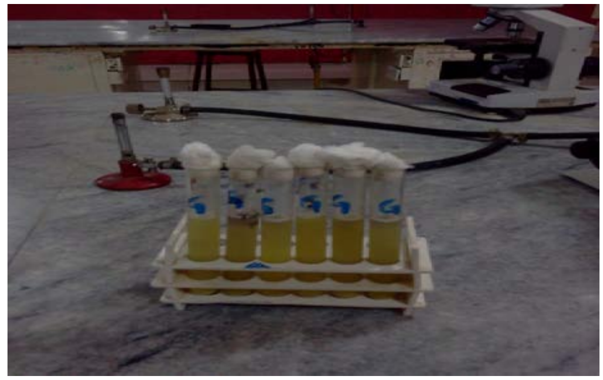

Fig.3. Macconky broth culter after 24hr before treatment

Fig.2. after treatment macConky broth culter after 48hr

Fig.4. Maconky after 48hr before treat

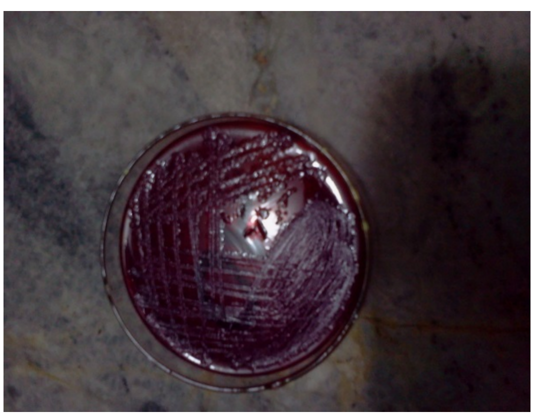

Fig.5. Dishes for germination test

Fig.6. Dishes for germination test