Available online at www.elixirpublishers.com (Elixir International Journal)

Petroleum Engineering

Elixir Petro. Engg. 86 (2015) 35395-35397

ISSN: 2229-712X

Oilfield Produced Water Treatment

Isemin A. Isemin*, Patrick N. Inyang and Daniel M. Okoro

Department of Chemical & Petroleum Engineering, University of Uyo, Uyo, Nigeria.

ARTICLE INFO

Article history:

Received: 21 August 2015;

Received in revised form:

25 September 2015;

Accepted: 30 September 2015;

Keywords

Produced water,

Waste generation,

Oilfield water pollution,

Petroleum production,

Recovery.

ABSTRACT

Produced water represents more than 80% of the volume of waste generated by activities in the oil and gas industry. This is an enormous waste and should be handled and disposed of in a manner that should avoid negative environmental consequences. This paper details laboratory analysis for the removal of some of the harmful chemical and physical properties. Produced water was collected from A-field in the Niger Delta using 250 ml sterile sample bottle. At the end of the analysis, results show that removal of these harmful properties is dependent on the type of treatment proffer as the individual properties have different characteristics of the produced water quality and its origin. Compounds such as aliphatic and aromatic hydrocarbons, polycyclic aromatic hydrocarbon, phenols, and other chemical product which are used to facilitate petroleum production recovery contribute to oilfield water pollution.

© 2015 Elixir All rights reserved.

Introduction

Extraction of oil and gas leads to a reduction in reservoir pressure, and as a result of this water is injected into the reservoir water layer to maintain hydraulic pressure and enhance recovery. In addition to the injected water, water breakthrough occurs from outside the reservoir area and as oil and gas production continues, formation water reaches production well and is produced alongside the hydrocarbon. This water is known as *produced water (or oilfield brine)* and accounts for the largest volume of by product generated during oil and gas recovery operations. Produced water is usually very salty and may contain suspended and dissolved solids, residual hydrocarbons, heavy metals, and chemicals used in hydrocarbon extractions.

In Nigeria, formation water is one of the major pollutants of the aquatic environment in areas where oil exploration and production activities are being carried out and has attracted much attention in the past. Globally, Oilfield formation water contains 3000 to 9000 mg/L chloride ions and continuous discharge of this water into fresh water environment has contributed to damage of aquatic and agricultural resources.

Currently, there is a stipulated rate of monitoring for produced water parameters in Niger Delta to checkmate Oilfields daily produced water. The specified monitoring frequency according to Department of Petroleum Resources (DPR) is once per week for production platforms and tank-farms for effluent characteristics such as temperature, PH, electrical conductivity, terminals, salinity, oil and grease, total organic carbon, and total dissolved solid (TDS). The monitoring frequency is once per year as requested by the Department of Petroleum Resources (DPR) for effluent characteristics such as hydrocarbon compounds and Naphthalene, Benzene, and Xylene. This paper entails the treatment of these properties of oilfield produced water in the Niger Delta A-field.

Produced Water

The water present in a reservoir along with hydrocarbons is called “formation water” and is named “produced water” when it is produced to the surface with the crude oil and/or natural gas. Produced water has different complex composition depending on geological conditions and field positions. Oil and grease concentration in produced water is an important factor for compliance monitoring as it is simple to measure (Arnold and Stewart, 2008). It is the commonly used factor for evaluating treatment system design since it consists of normal paraffinic, asphaltic and aromatic hydrocarbon compounds plus treatment chemicals.

Treatment of Produced Water

Current oil and grease removal treatments include API gravity separators, corrugated plate separators, hydrocarbons, mesh coalescers, media filters, centrifuges, membrane filters, and flotation. While gravity separation is ineffective with small oil droplets, the API segregator reduces the oil droplet size, and the corrugated plates can further remove oil droplets size. However, current technology by Saipem and Veolia have been design that offers the combination of flexibility and robust performance, allowing operators to treat produced water to the requirements of the reservoir rather than having to accept the limitations of bulk separation systems.

Dispersed Oil

Produced water contains hydrocarbons in the form of dispersed oil droplets which under proper conditions can be coalesced into a continuous hydrocarbon liquid phase and then separated from the aqueous phase using separation devices. The amount of dispersed oil in a producing water stream varies depending on factors like oil density, shear history, control valves, pumps (Arnold and Stewart, 2008), and interfacial tension (IFT) between the water and the oil (Stephenson, 1992).

Dispersed Oil Removal

Produced water streams containing high concentrations of dissolved oil can be recycled to a fuel separator to help reduce the quantity of dissolved oil in the water effluent. In the last 20 years, deoiling hydrocyclone has become the workforce of the offshore industry where skim tanks and plate separators have been commonly used as the first stage in removing dispersed oil from produced water.

Tele:

E-mail addresses: iseminisemin@uniuyo.edu.ng

© 2015 Elixir All rights reserved

Table 1. chemical and physical parameters of produced water

Parameters	Before treatment	After Treatment	DPR Treatment	EGAS - PIN	%Removal After Treatment
Temperature (°C)	30.1	12	28.70	25	60.10
pH @ 30.1°C	7.54	6.10	6.83	6.5 - 8.5	19.10
conductivity (ohms/cm)	126.5	23.10	116.1		81.80
Turbidity (NTU)	22	4.50	19	>10	79.50
Salinity (ppm)	2800	520	1800	600	81.40
Alkalinity (mg/l)	84	8			90.50
Oil and Grease (ppm)	61.61	4.20	55.1	10	93.10
Total Dissolved Solids (ppm)	3100	1980	2800	2000	36.10
Total Suspended Solids (ppm)	138	26	94	>30	81.20
Biochemical Oxygen Demand (mg/l)	17.68	2.30	4.50	10	86.90
Dissolved Oxygen (mg/l)	7.67	3.60	7.81		53.10

Table 2. Concentration of Trace Metals in Produced Water Samples

HEAVY METAL	Before treatment	After Treatment	DPR Treatment	EGAS PIN	%Removal After Treatment
Sodium	0.20	0.001	0.44		99.50
Calcium	0.10	0.001	0.19	0.05	99.00
Magnesium	1.40	0.10	1.90	1.00	92.90
Barium	0.01	0.001	0.04	0.03	99.80
Strontium	0.41	0.001	0.61	1.00	99.40
Iron	0.16	0.02	1.90		87.50
Boron	0.4	0.04	0.08		87.5

Though conventional induced gas flotation (IGF) equipment has been used for several years to remove oil with a retention time of 5 minutes, a Compact Floatation Unit (CFU) has been developed to reduce space and weight in offshore applications with a retention time of between 1 and 2 minutes. This is achieved by causing the produced water to swirl the rotation plug flow giving improved separation efficiency.

Methodology

Materials

All chemicals and reagents used were of annular grade. Anhydrous salt were properly dried and desiccated before used. Distilled water was used for all reagent preparations and dilutions. Analytical balance was used for weighing samples. Standard stock solution for spectrometer was prepared from the pure metals and in some cases, their salts. Copper and zinc standards were prepared from their metals by dissolving with concentrated nitric and hydrochloric acid respectively. Nickel, cadmium, and manganese standards were prepared from their acetate salts.

Instruments

Mercury in glass thermometer was used for temperature measurement. EIL 7050 combined PH/conductivity meter was used for pH and conductivity measurement. For weighing samples, the H43 meter weighing balance was used. The Biochemical Oxygen Demand (BOD) measurement was performed at a temperature of 20°C using a special 100ml BOD bottle.

Methods

All properties under investigation were conducted separately. For the turbidity, samples of the produced water were poured into a tube and then stirred thoroughly to allow for air bubbles escape. The tube was then dried before lowering into the turbidity meter to take readings. For the alkalinity, 100ml of the oilfield water was pipette into a baker followed by addition of 5 drops of phenolphthalein indicator and the titration of Sulphuric acid into same baker. Mixture was stirred until the change in color got to its endpoint. Total Dissolved Solids (TDS) was measured as a function of conductivity using the conductivity meter at a sample temperature of 25°C. The temperature and pH were measured on-site. A direct Atomic Absorption Spectrometer was used for calcium and magnesium determination. The effect of TDS on metal removal from produced water was done with a cation exchange column using different flowing rate was reported (fig. 1). To remove boron from the produced water, water was prepared in the laboratory using metal salts with different TDS of 1980 and 3100 PPM TDS respectively (fig. 2).

The sampling was done daily and the weekly average taken for six months. Table 1 shows the physical, chemical, and other parameters of water quality before and after treatment. The regulatory limit of each of the parameters is also included in the table.

Results and Discussion

Analysis of test parameters: Before treatment, the temperature was above the regulatory prescribed limit of 28.70°C. However, it was reduced to 12°C after treatment. This was achieved after the temperature was passed through a cooling tower followed by a shallow cooling trench from 30.1°C. An increase in temperature increases the calcium carbonate scaling tendencies. Although before measurement, the pH value was 7.54 which were within allowable limits but it further reduced to 6.10 due to CO_2 / bicarbonate controlling the system. The variation in turbidity measurement plays a major role in water treatment as it is used to determine if a supply requires special treatment by chemical coagulation and filtration. Salinity values were reduced from 2800 mgL^{-1} before treatment to 520mgL^{-1} after treatment which meets the minimum requirement of 600 mgL^{-1} set by the regulatory body. It should be noted that high dissolved salt content in injected produced water has the potential for scale formation i.e. calcium carbonate and barium sulphate. TDS which is a reflection of suspended and dissolved ions inherent in the produced water was also reduced after treatment. A proper treating facility reduces TDS as well as heavy metals and dissolved salts. Total Suspended Solids (TSS) reduction was achieved efficiently with the help of the different process of the produced water facility.

Analysis of Trace Heavy Metals: this is normally done to ascertain the degree of produced water toxicity before its discharge into the environment.

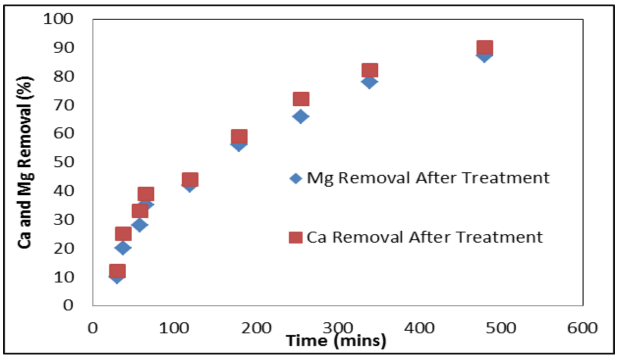

Fig. 1. Effect of TDS on the removal of calcium and magnesium from produced water.

As shown in table 2 is the concentration of trace metals with all of the metals having met the required regulatory limit exception of Boron. Sodium was used to adjust cation-anion balance (in water analysis), determination of TDS, and determination of ionic strength (used for scaling tendency calculations). Figure 1 shows the effect of 1980ppm TDS of on Ca and Mg after treatment. The calcium ion combines with carbonates, bicarbonates and sulphate to form calcium and calcium scale while the magnesium is a factor in forming dolomite which is a magnesium carbonate scale. Figure 2 shows the 3100ppm TDS before treatment and 1980ppm TDS after treatment on Boron. Results shows that a proper reduced TDS help in reducing Boron from produced water.

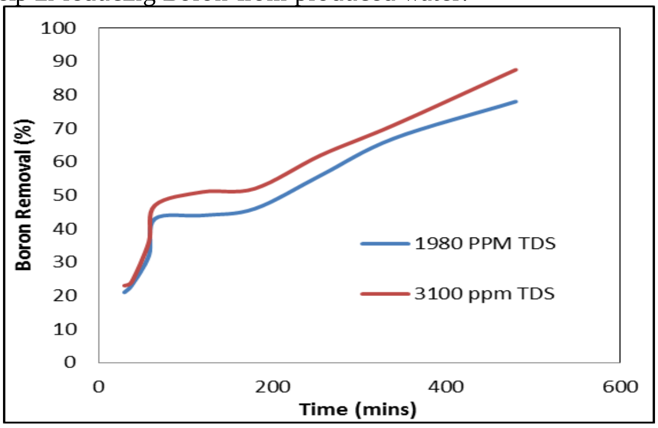

Fig. 2. Effect of different amounts of TDS on the removal of boron from produced water.

Conclusion

Field observation shows that produced water is responsible for many problems like corrosion, scale, microbial growth and dirty equipment. Chemical analysis of the produced water from drilling locations is required to cover the wide range differences in the chemical and physical properties of water.

The individual properties are dependent on the geological formation, the geophysical location of the reservoir, lifetime of the reservoir, and the type of hydrocarbon produced in the Niger Delta area of Nigeria. This factor determines the type and concentrations of inorganic species in formation water. However, as observed from the field is that some physical-chemical properties of the produced water are somewhat higher than the regulatory limit for discharge into the environment therefore treatment is required before disposure.

Reference

Arnold, K. and Stewart, M. 2008. Surface Production Operations: Design of Oil Handling Systems and Facilities. Vol. 1, Ed. 3, Gulf Professional Publishing Co., Burlington, MA.

Ashahl, S., and Rabe, K. 2013. Real-Time Automatic Operation and Optimization of Produced-Water Treatment. SPE paper 167492 presented at the SPE Middle East Intelligent Energy Conference and Exhibition, Dubai, UAE, October 28-30.

ASTM International. 2011. Standard Test Methods for Oil and Grease and Petroleum Hydrocarbons in Water. ASTM, D3921-96.

Boysen, D.B., Boysen, J.E.. and Larson, T. 2002. Regional, Technical, Regulatory and Economic Trends in Produced Water Management. Gas Research Institute.

. Clark, C.E. and Veil, J.A. 2009. Produced Water Estimates and Management Practices. SPE paper 125999.

Dorang, G. and Leong, L.Y. 2000. Developing a cost effective solution for produced water and Creating a New Water Resources. United State Department of Energy. National Energy Development Laboratory DOE/MT/95008-4.

Enrique, L., Tyley, N. and Dru, M.B. 2015. Achieving a Stable Native Guar Boron Crosslink in 100% Produced Water. SPE Paper 173735 presented at SPE International Symposium on Oilfield Chemistry, Texas, USA. April 13-15.

Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN). 2000.

Hill, F., Monroe, S. and Mohanan, R. 2012. Water Management – An Increasing Trend in the Oil and Gas Industry. Paper SPE 154720, presented at the 2012 SPE/EAGE European Uncoventional Resources Conference and Exhibition held in Viena, Austria, 20-22 March.

Obanijesu, E. O., Dada, E. O., and Bello, O. O. 2007. Use of diatomaceous Materials for Recovery of Heavy-Metals from Oil and Gas Produced Waters. SPE 106557, Paper Presented at Environmental and Safety conference held in Galveston, Texas, USA.

Patil, A., Nanda, J., and Waikar, J. 2015. Treatment of Produced Water Using Chelating Resins: Laboratory Case Study. SPE Paper 173742 presented at SPE International Symposium on Oilfield Chemistry, Texas, USA. April 13-15.

Stephenson, M. 1992. Components of Produced Water: A comparison of Industry Studies. *Journal of Petroleum Technology*. Vol. 548-603.