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Oil in Water, Radioactivity, Physical and Chemical properties Study for Produced Water from Heglig and Neem Oil Field

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Abstract: This study investigates the physical and chemical parameters, heavy metals, oil contents and radioactivity of Neem and Heglig field produced water to find adequate technique to be used for treatment of pollution measurements that exceed the limits of environmental legislation. For Heglig produced water all the analysis results were within the acceptable limits according to Ministry of Energy and Mining except for the oil content, TDS, NH_3 and Fe which exceeded the allowable limits because of the cumulative effect due to the evaporation. Moreover, conversion of Heglig field produced water into a source of fresh water is feasible for field scale application by using bioremediation technique for oil in water treatment. For Neem field produced water the results of total hardness, alkalinity, pH, TDS, and E conductivity exceeded the acceptable limits according to Ministry of Energy and Mining and the elements Pb, Ag and radioactivity exceeded by a large margin the acceptable limits while the result for oil in water was less than 1ppm, which is in the acceptable limit. Bioremediation treatment for Neem field produced water is useless, and the plantation of *Phragmites Australis* is suggested to be replaced by phytoremediation plant such as (*Brassica juncea L, Sorghastrum nutans, Helianthus annuus, Gleditsia triacanthos, and Brassica)* for treatment of heavy metals (Pb and Ag) that exceed the acceptable limits.

Keywords*: Phytoremediation, bioremediation, produced water, radioactivity*

Introduction

Communities across the world face water challenges due to increasing demand, drought, depletion and contamination of groundwater, and dependence on single sources of supply. There has been a push in recent times towards water reclamation, recycling and reuse to address these challenges (Hansen and Davies, 1994).According to the US Department of Energy (DOE), the term "produced water" has been assigned to water trapped in underground formations and brought to the surface along with oil or gas. The idea being that these are waters "produced" during operations or extraction of energy containing materials-fossil fuels-from the earth. Produced water is a natural aqueous fluid that is produced from oil reservoir in association with the hydrocarbon (USDOE, 2010). Despite its significance, petroleum is produced with large volumes of waste, with wastewater accounting for more than 80% of liquid waste (Azetsu-Scott, et al 2007). Typically the produced water is separated from crude through process and treatment facilities and is the largest volume of product generated during oil and gas recovery operations. The rate of oilfield produced water production is expected to increase as oilfield ages. There are many international and local laws and regulations for the industrial and municipal waste waters to be treated properly prior to disposal (in the existing ground and/or surface water resources). This always makes it very difficult and expensive for both municipalities and industrial sectors. Challenges are always focusing on trying to find the best and cheapest way to cope with these restrictions. Environmental concerns and the prospect of beneficial uses have driven research into the treatment of produced water. After treatment, produced water may still contains dissolved and dispersed oil components, heavy metals - arsenic, lead, cadmium, copper, chromium, mercury, nickel, zinc, radionuclides, production chemicals, dissolved gases (including CO_2 and H_2S) and produced solids (Reynolds, 2003). There is a wide variation in the level of its organic and inorganic compositions due to geological formation, lifetime of the reservoir and the type of hydrocarbon produced. Produced water has a complex composition, but its constituents can be broadly classified into organic and inorganic compounds (Hayes, 2004). including dissolved and dispersed oils, grease, heavy metals, radionuclide's, treating chemicals, formation solids, salts, dissolved gases,

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scale products, waxes, microorganisms and dissolved oxygen (Fakhru'l-Razi, et al 2009). The Objectives of this study are to propose processing technology for pollution measurements that exceed the limit of Sudanese Ministry and Mining legislation, and to produce clean Water and recover valuable materials from produced water with minimal negative impact on the environment.

Materials and Methods

During the study some water samples were taken from the outlet water line of CPF in Heglig field. And other water samples were taken from the outlet water line of Neem FPF (last bond) in Neem field. Analar grade chemicals and Analytical Grade Reagent were used in analysis. The following instruments and apparatus (Spectrophotometer -HACH DR 5000, gamma spectrometer- LB 200 Becquerel Monitor BERTHOLD, inductively coupled plasma optical emission spectroscopy (ICP-OES) - Varian-vista-MPX-CCD, rotary evaporator – steroglass 202, pH/mV/°C meter - HANNA 213, EC/TDS/NaCl/C° Meter - HANNA HI 9835, burettes, volumetric flasks, conical flasks, beakers, pipettes, sensitive balance, water bath TC 502, Duran sample bottle, droppers, cuvette 1 cm, separatory funnel, 1-L, with TFE stopcock and liquid funnel, glass) ware used in the determination of heavy metals, oil contents, total hardness, alkalinity, pH, TDS, E-conductivity, NH_3 as N_2 and radioactivity analysis. Materials used, experimental equipment, experimental procedures and sampling procedures are all according to American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF), Standard Methods for the Examination of Water and Wastewater (Joint Editorial Board and Committee Members, 20th Ed.).

Results and Discussion

The results of oil in water for Produced Water from Heglig oil field before and after treatment by bioremediation system applied for hydrocarbons removal by using *Phragmites Australis* plant are given in (Table 1), physical and chemical properties, heavy metals and radioactive for Heglig oil field produced water are given in (Table 2). (Table 3) presents' physical and chemical properties, heavy metals, radioactive and oil content results for Neem oil field produced water.

Table 1. Oil content in water results for Heglig field produced water

Test method For oil content	Test method standard	Unit	Results	
			Before treatment	After treatment
Oil content gravimetric	APHA 5520 B	ppm	6	Nil
Oil content spectrophotometer	APHA 5520 C	ppm	9	1
Oil Content IR Oil analyzer	APHA 5520 D	ppm	11.30	1.5

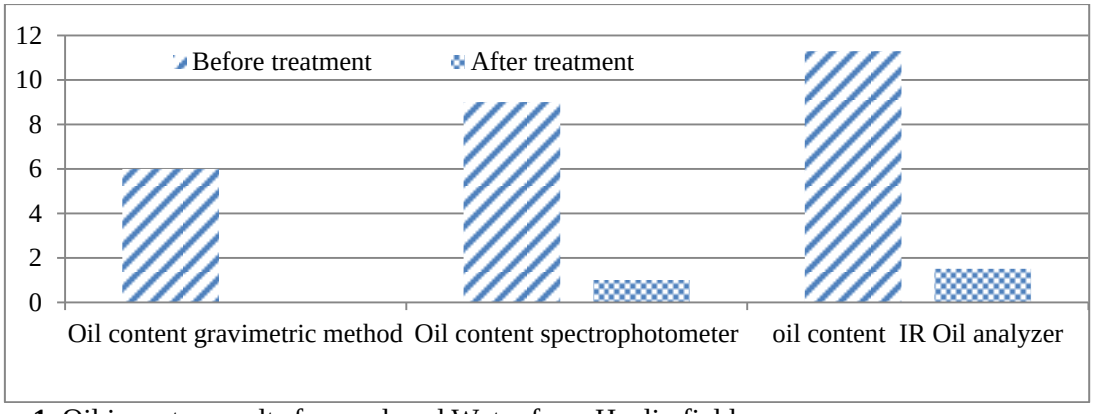

Figure 1. Oil in water results for produced Water from Heglig field

From oil content results in (Table1) all methods showed that oil content after treatment is decreased and cope to acceptable limit of 5 ppm according to the regulation of Sudanese Ministry of Energy and Mining. Comparing between the obtained results from the above three methods it was found that the determination of oil content by IR method seem to be more accurate than by spectrophotometric and gravimetric method. Conversion of Heglig field produced water into a source of fresh water is feasible

for field scale application by using bioremediation technique via Phragmites Australis plant that can treat a large part of the oil in water.

Table2. Physical and chemical properties, heavy metals and radioactive results for Heglig produced water.

Test method	Test method standard	Unit	Result	Accepted limit
Total hardness	APHA 2340 C	mg/l	210	---
Alkalinity	APHA 2320 B	mg/l	230	--
pH	APHA 4500-H^+	—	9.10	6 - 9
TDS	APHA 2540	mg/l	1502	1200 mg/l
E conductivity	APHA 2510	µS/Cm	3040	
NH_3 as N_2	EPA 10205	mg/l	0.25	Nil
Zn	APHA 3120	mg/l	0.002	1
Fe			1.593	1
Pb			0.01	0.05
Ni			0.029	0.1
Cd			0.0009	0.01
Ag			0.004	0.01
Radioactivity	APHA 7120B	Bq/l	Nil	Nil

From the results in (Table 1) above for Heglig produced water all, the analysis results were within the acceptable limits according to Ministry of Energy and Mining except for the oil content, TDS, NH_3 and Fe that exceeded the allowable limits.

Table 3. Physical and chemical properties, heavy metals, oil in water and radioactive results for Neem produced water

Test method	Test method standard	Unit	Result	Accepted limit
Total hardness	APHA 2340 C	mg/l	420	120
Alkalinity	APHA 2320 B	mg/l	7250	--
pH	APHA 4500-H^+	---	10.71	6 - 9
TDS	APHA 2540	mg/l	7650	1200 mg/l
E conductivity	APHA 2510	µS/cm	13520	
NH_3 as N_2	EPA 10205	mg/l	Nil	Nil
Oil content	APHA 5520 D	mg/l	0.86	5
Zn	APHA 3120	mg/l	0.014	1
Fe			0.040	1
Pb			0.335	0.05
Ni			0.0510	0.1
Cd			0.012	0.01
Ag			1.74	0.01
Radioactivity	APHA 7120B	Bq/l	<21	Nil

From the results in (Table 3) for Neem field produced water the results of TDS, pH, Pb, Ag and radioactivity exceeded the allowable limits according to Ministry of Energy and Mining while the result of oil content is within the acceptable limit.

Conclusions and Recommendation

This paper covers the studied oil content in water, physical and chemical properties, heavy metals and radioactivity of produced water in Heglig and Neem field.

Following conclusions can be drawn from this study:

1. For Heglig produced water all the results obtained were within the acceptable limits according to Ministry of Energy and Mining except for the oil content, TDS, NH_3 and Fe. Moreover, conversion of Heglig field produced water into a source of fresh water is feasible for field scale application by using bioremediation technique via *Phragmites Australis* plant that can treat a large part of the oil in water. The values of other contaminants of produced water are not large; and that shown the efficiency of Bioremediation system.

2. For Neem produced water the value of oil in water is less than 1ppm, so bioremediation treatment *Phragmites Australis* plant is useless, and the plantation of *Phragmites Australis* is to be replaced by phytoremediation plant such as (*Brassica juncea L, Sorghastrum nutans, Helianthus annuus, Gleditsia triacanthos, and Brassica)* to be used for treatment of heavy metals (Pb and Ag) that exceed the acceptable limits (Marzena & Anna, 2011).
3. For Neem produced water desalination, further analysis is need by effective technologies such as Solvay processes that consist of the reaction of sodium chloride with calcium carbonate to produce soda ash. The main raw material in the Solvay process is the sodium chloride and the produced water contains high levels of salt. The advantage of using Solvay processes for Neem produced water is not only their proper treatment, but also that they provide new sources of soda ash that may be important to industries (Castro, et al 2013).
4. Further analysis of the radioactivity of Neem produced water should be conducted using technique that is more accurate.

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