Evaluate of Biological Activity to Industrial Waters Used into Baghdad East/Rashidiy Oil Field

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Abstract: This study was conducted on the biological evaluation to various water used in the oil fields. The East Baghdad/Rashidiy “EBR” oil field was one of Midland Oil Company “MdOC” fields which was chosen as a case study located, where biological tests carried out such as the sulfur reducing bacteria SRB test, Total count aerobic bacteria TCB test, and the biological oxygen demand BOD test to four water samples collected from different locations of the ERB oilfield which was referred: service water, water cut, oily water, dehydrator Water during four seasons between 2023-2024. The observed result to samples studied showed, growth of sulfur-reducing bacteria with clearly differentiated growth of aerobic bacteria species through four seasons. Also, an increase of the biological oxygen demand (BOD) values which indicating bacterial growth and metabolism may lead to a problem with the biological water treatment processes, either due to the efficiency or quantity of the bio inhibitor agents. Furthermore, the H_2S concentration, responsible for corrosion, sedimentation, and odors, was elevated beyond permissible limits, and the oil content in the oily water samples was also high. The presence of oil in water can lead to soil and groundwater pollution and damage ecosystems.

1 INTRODUCTION

The oil and gas sector from industries is massive and complex system consists from three main phases (Upstream, Midstream, and Downstream) which process begins production of valuable petroleum products [1], [2].

Biological evaluation to water used in oil fields has benefits due to importance of water in all stages process of oil and gas production, from extraction and washing to treatment. Produced water “water cut” was comesout of oil wells with oil and gas ,naturally and there is water used during the separation processes of crude oil, it’s containing chemical and biological pollutants that can affect the environment if not managed properly. Biological assessment was aimed to study the presence and detect type of some microorganisms in watery sources within the oil field, as microbial growth has both positive and negative effects to ecosystem [3].

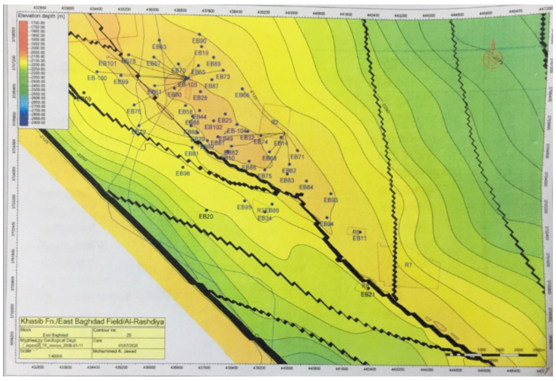


Figure 1: The well locations in the ERB oilfield.

The East Baghdad field located in the area extending from east of the city of Al-Suwaira in the southeast to the Al-Naba'i area in the northwest, crossing east of the center of Baghdad, and MdOC is considered one of the company's most important oil fields. The company has several wells drilled in the field, distributed between (the first and second southern areas, the residential area, the Rashidiya area, the Taji area, and the Naba’i area), consisting of

66 wells, as shown in Figure 1. The field's production capacity is about 9,500 barrels per day, with an associated water quantity ranging from 1.5% to 2.7%.

Oil spills and leaks from pipelines and storage tanks pollute rivers, lakes, and oceans, harming aquatic life and impacting human health [4]. Regarding rock pollution, exploration, drilling, and process production activities can lead to soil contamination, land degradation, deforestation, disruption of ecosystems, and damage to biodiversity [5].

The oil fields contains various types of microorganisms, referred to as"oilfield bacteria" which can be classified based onto metabolic activity and effects[6] like as: methanogenic bacteria**,** as a group of methane gas CH_4 producing as end product of its metabolic process, its strict anaerobic, have ability to withstand high temperature, itsfound in various environments as swamps and oil associated water, its ability to reduce carbon compounds C1 or other organic substrates to methane [7] . Sulfate-reducing bacteria (SRB), its obligate anaerobic bacteria, has ability to oxidize organic materials to sulfur compounds such as SO_4^{-2}, SO_3^{-2}, $S_2O_3^{-2}$. It has reduced sulfur compounds to H_2S gas, which is an oxidizing agent for organic materials, thus obtaining energy, as in the following reaction [8], [9]:

$$4H_2 + SO_4^{-2} + 2H + \rightarrow H_2S + 4H_2O + \text{Energy}.$$

It has grown ranges from -5 to 75°C with pH between 5.5 and 9.5. Although these bacteria are anaerobic, some species can grow in the presence of low concentrations of oxygen [10]. Sulfate - Oxidizing Bacteria, its bacterial group derive their energy from sulfur compounds oxidation such as hydrogen sulfide (H_2S), it's can divide based on their metabolic function into two groups: chemical and optical [11], [12], Depended onto direct and indirect techniques for sulfur oxidation [13]. Acid- producing bacteria, an important group of corrosive bacteria in the economic system, importance to the petroleum industry, it's a form primitive colony resulting from aerobic metabolism and produce large quantities of organic: compounds and acids, because they have ability to grown in the pH equal to one [14], that contributes to the continuation of the corrosion process. The acidity of the surrounding environment was a factor to these bacteria were observed during laboratory testing in the corrosion products of pipelines, Among the genera isolated were *Klebsiella*, *Pantoea*, *Escherichia*, *Providentia*, *Proteus*, *Shewanella*, *Myroides* and *Pseudomonas* [15].

Iron-associated bacteria, found in soil, shallow groundwater, sewers and surface water, used iron and oxygen in their metabolism and adheres to pipes and pumps. it's feed on a wide range of substrates and under a variety of reduction and oxidation conditions. Iron - associated bacterial species *Gallionella*, *Crenothrix*, *Sphaerotilus*, *Siderocapsa*, and *Thiobacillus Ferroxidans*. Iron-associated bacteria belong to different groups, making them difficult to enumerate [16]. Iron-reducing bacteria have been discovered in most oil fields. These bacteria can also convert sulfur, sulfite, and thio-sulfite into sulfide [17].

This study was aims to evaluate the bacteriological activity of water in oil fields by monitoring of biological bacteria activity to ensure optimal operation and reduce the potential negative effects of these bacteria on equipment and machinery, which lead to achieving of main objectives of the biological assessment of oil fields which includes: prevent bacterial corrosion, improving the quality of oil and gas, reducing environmental problems, ensuring the health and safety of workers, improving processing efficiency, reducing maintenance costs, compliance with environmental laws and regulations.

2 MATERIAL AND METHODS:

2.1 Sample Collection

Water samples were taken as two repeated samples from each located in ERB oilfield detected which showed in b, it collected into tow bottle which one is sterile, tightly sealed 500ml glass bottles used for biological testing, and another in 1000 ml bottles used for chemical testing. Figure 2 on the right side shows sampling locations on Google Maps.

Water studied type taken include, service water, water cut, water dehydrator, oily water showed in the right-side Figure 3 All samples were transferred immediately to the environmental pollutants Laboratory of HSE/MdOC for biological and chemical testing.

2.2 Laboratory Testing:

2.2.1 Physiochemical Tests

pH, conductivity, temperature, turbidity, total hardness, total dissolved solids, suspended solids, and oil content was performed physical tests used in the Langelier Saturation Index (LSI) which used into detect of behavior, tendency and determining of water towards causing erosion or sedimentation [18].

2.2.2 Biological Tests

Biological tests like, Dissolved Oxygen DO_2, Biological Oxygen Demand BOD, Chemical Oxygen

Demand COD, Sulfate Reduce Bacteria SRB for (anaerobic bacteria), Total plate Count Bacteria TCB, and microscopic diagnosis.

Figure 2: Locate samples by Google map.

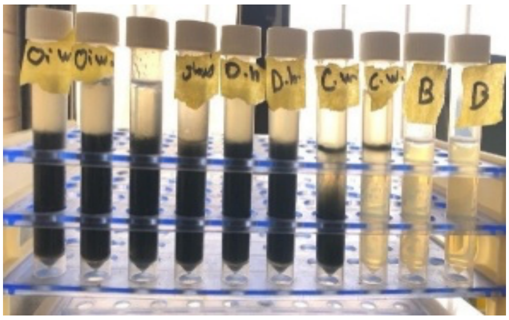


Figure 3: Water samples were studied.

2.3 Prepare Media and Chemical Agents Used

The following culture media and chemical reagents were prepared and used throughout the study:

1) Nutrient Agar media (NA), Nutrient Broth Liquid Media (NB), MacConkey Agar media (MaCA), hromogenic UTI Agar media (Chrom) were prepared according to their manufacture instruction (Hi-Media, India).
2) SRB Kit (Lovibond, German)) for testing anaerobic sulfur reducing bacteria that indicated by the turns black in the presence of sulfur-reducing bacteria, indicating their production of iron sulfide.
3) Gram stain set (Lovibond, German) used into distinguish of shape and differentiated between Gram-positive and Gram-negative bacteria.

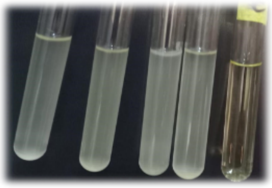


Figure 4: NB turbidity indicated to growth of aerobic bacteria.

3 RESULTS AND DISCUSSION

3.1 Biological Analyses results: were shows follow

The microbiological examination revealed the following observations:

I. A clear growth of SRB bacteria was subsequently observed as shown that in Figure 4 with black area as indicator to H_2S produced.

II. NB turbidity was observed that indicated to presence of bacteria growth especially aerobic bacteria presence compared to blank sample, as shown that in Figure 5. Also, a small bacterial colony showed onto surface of NA as shown that in Figure 6 lead to growth of aerobic bacteria.

Also, a small bacterial colony showed onto surface of NA as shown that in Figure (6) lead to growth of aerobic bacteria.

III. observed of the spherical, rod-shaped, and oval bacteria appeared microscopically which differentiated between positive and negative by used Gram staining as shown that in Figure 7 a and b.

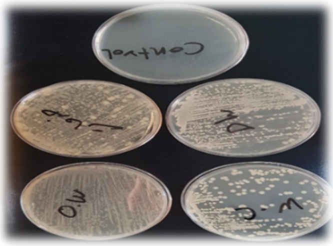
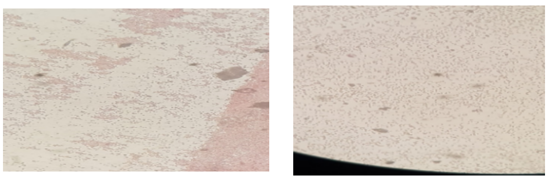


Figure 5: SRB results with black zone compared to blank sample.



(a) (b)

Figure 6: Bacterial shaped under microscope.

Figure 7: Color discrimination between positive and negative using Gram stain.

Observed of some bacterial species grow onto Chrom media as *Enterococcus faecalis* and *Klebsiella pneumoniae*, mentioned in Table 1.

According to the above results of the biologic tests in Table 2, there is variation in the bacterial growth were observed studied, which is as follows:

1) Growth of *Enterococcus fecalis*, was observed into service water samples, with black dense appearing due to growth of SRB after 48hrs of culture.
2) Increase in value The BOD_5, which indicates to the presence of widespread growth of aerobic bacteria, and consequently greater oxygen consumption in oily water samples, along with the appearance of growth of SRB, also identified of *Enterococcus fecalis* in oily water sample.
3) A rise in the value of BOD_5, for the same reason mentioned above in the dehydrator water samples, and dense growth of SRB was observed, also identified *Klebsiella pneumoniae* observed.
4) Water Cut: Increase in value The BOD_5 For the same reason mentioned in point number 2 above, noting the appearance of dense growth of SRB, as well as the growth of a spherical aerobic bacterium as *Enterococcus fecalis*.

According to biological tests summary in Table 2, this study was suggested to the sources routes and effected of bacteria detected which mentioned in the below Table 3.

Table 1: Bacterial Spp. with properties.

Bacterial SPP. Distinguished	Bacterial properties
Enterococcus faecalis	Gram-positive bacterium, spherical or oval in shape, and can grow in diverse environmental condition [19]
Klebsiella pneumoniae	Gram-negative, rod-shaped bacterium [20]

Table 2: Summary of biological results tests to water samples studied.

Model name	DO_2	BOD_5	SRB bacteria	Growth of aerobic bacteria	Spp. bacteria
Blank	-----	-----	Negative	Negative	Nil
Service Water	7.9	2.25	Positive	Positive	Enterococcus fecalis
Water Cut	1.6	385	Positive	Positive	Enterococcus fecalis
Water Dehydrator	1.3	605	Positive	Positive	Klebsiella pneumoniae
Oily Water	1.15	775	Positive	Positive	Enterococcus fecalis

Table 3: Source and bacteria effects.

Bacterial SPP. Distinguished	Source routes	Bacterial effects
Enterococcus faecalis	1) Watery pollution. 2) Contaminated pipelines	1) Biological erosion for pipelines and oil equipment, which cause material losses. 2) Pollution of petroleum products, which affects their quality. 3) The health risks for workers when dealing with these bacteria through contaminated water or soil can be a health hazard, especially if the bacteria are resistant to antibiotics.
Klebsiella pneumoniae	1) Polluted water or polluted soil. 2) Water used in extraction or treatment processes was contaminated. 3) Contaminated equipment.	1) Contribute in the biological corrosion of pipes and equipment, leading to material losses. 2) Oil product contamination can affect the oil quality and products. 3) A health risk can arise as a result of workers being exposed to these bacteria through contaminated water or soil. There can be a health risk, especially if the bacteria are resistant to antibiotics.

3.4 Results of the Chemical Tests

Numerous chemical tests were carried out on the samples studied where used in the Langerhans index, the results were as follows, as shown in Table 4:

Table 4: The results of the chemical tests. Note: ORD: Over rang detected due to the high concentration of oil.

Test	Service Water	Oily Water	Water Dehydrator	Water Cut
PH	8.1	7.014	6.968	6.586
TSS (mg/L)	0	152	136	ORD
Turb (NTU)	6.1	127	74	ORD
EC (µs/cm)	730	66500	68800	193200
TDS (mg/L)	665	59455	58460	236250
TH (mg/L)	352.8	11760	12740	47040
Ca^{+2} (mg/L)	70.56	2940	3136	13720
Mg^{+2} (mg/L)	42.3	1058	1176	3057
M.AL (mg/L)	225.7	97.6	115.9	146
$SO^{=}$ (mg/L)	225.579	6115	5644.8	20697
Cl^{-} (mg/L)	56.2	29258	29785.4	143391
COD (mg/L)	9.0	3100	1680	1540
H_2S (mg/L)	1.66	8.33↑	4.998↑	3.33
Oil in Water (mg/L)	0.2	296.4↑	13.4	10.2

The results showed in above table as the following:

- Increase observed of H_2S concentration in the dehydrator water and oily water more than observed into water cut and service water samples that lead to increase causes corrosion of the pipes and equipment. It can react with oxygen to form sulfates or solid sulfur. These compounds can cause pipe blockages or the formation of deposits on the inner walls of pipes. H_2S A strong and unpleasant odor, which can lead to problems with the ventilation system or the spread of odors to surrounding areas; the presence of H_2S It can encourage the growth of certain types of bacteria that contribute to the biological corrosion of pipes, leading to additional problems.
- Hyper increase in the amount of oil in water in the oily water sample more than other studied samples, leads to pollution of soil, groundwater and rivers, and can affect living organisms and harm ecosystems.
- High value of COD to the oily water, water cut, and dehydrator water samples than service water sample may lead to a decrease in water quality, making it unsuitable for various uses and potentially affecting production operations in oil fields.
- The result of LSI equation to service water showed, tendency for the water to form $CaCO_3$ deposits as well as other studied samples tends to cause slight corrosion and no deposits.

4 CONCLUSIONS

The findings of this study lead to the following conclusions:

- The presence of corrosion phenomena in the pipes connecting Dehydrator Water and Oily Water is attributed to the growth of microorganisms.
- High levels of H2S cause corrosion in the pipes, in addition to deposits forming inside the pipes, which cause blockages.
- High BOD5 level This indicates the presence of high bacterial growth leading to the consumption of dissolved oxygen, which helps the activity of anaerobic bacteria (SRB).
- The appearance of sulfur-reducing bacteria growth in all water samples indicates that the currently used bio-inhibitor is inefficient, or that the current added dose is insufficient, or that the inhibitor was not added.
- The presence of microorganisms in general, which have been identified, confirms that no chemicals such as biostainers and corrosion inhibitors have been added for cumulative periods of time.

RECOMMENDATIONS

Based on the obtained results, the following recommendations are proposed to reduce microbiologically influenced corrosion and improve water management:

1) Periodic check-up water tests to detect the presence and growth of bacteria by using advance techniques.

2) Biocides Regular use of biosuppressants to control bacterial growth as chlorates, glutaraldehyde, and sulfur-based bio-inhibitors.
3) Rotation between inhibitors to avoid the development of bacterial resistance, different types of biosuppressants can be rotated.
4) Reduced nutrient intake by controlling organic matter and nutrients that may promote bacterial growth in water.
5) Maintaining oxygen levels to prvent growth of SRB.
6) Use of anti-corrosion chemicals in conjunction with bio-inhibitors to protect pipes and equipment.
7) Applying protective coatings to pipes and equipment to prevent corrosion caused by bacterial activity.
8) Using technology: Using advanced technology such as remote sensing and smart monitoring to analyze water in real time and detect problems early.
9) Regarding Oily Water This water should be used for reinjection into the reservoir in order to increase secondary oil recovery, especially given the problem of water scarcity for various applications such as drinking water, irrigation water, and industrial water.

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