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Fig. 8 Effect of biocides types, concentrations and water sources for SRB eradication

## 10. Conclusions

From the previous study we can concluded the following:

1. Ghani oilfield has three different classes of oilfield water namely (a) water from water source wells, (b) produced water from sour crude oil formations, and (c) produced water from sweet crude oil formations. All the three types of water are contaminated with sulfate reducing bacteria.
2. The presence of sulfate reducing bacteria generates hydrogen sulfide ($H_2S$) which causes rotten egg like smell, and it is a toxic gas. The presence of $H_2S$ is a cause of corrosion and environmental impacts.
3. Three different classes of biocide chemicals were tested for eradication of sulfate reducing bacteria in the Ghani oilfield. Time kill test procedure was adopted to evaluate the performance of biocide chemicals.
4. The biocide chemicals were obtained from Jowfe Oil Technology Company. The biocide formulation based on phosphonium compounds as an active ingredient is the most suitable chemical for eradication of sulfate reducing bacteria. The biocide formulation based on quaternary ammonium compounds as active ingredient did not show satisfactory performance. The chemical formulation based on glutaraldehyde as an active ingredient, also showed satisfactory performance results for eradication of sulfate reducing bacteria in the Ghani oilfield.
5. So we can use the effective types of biocide chemicals for eradication of sulfate reducing bacteria to avoid any problems in petroleum facility.

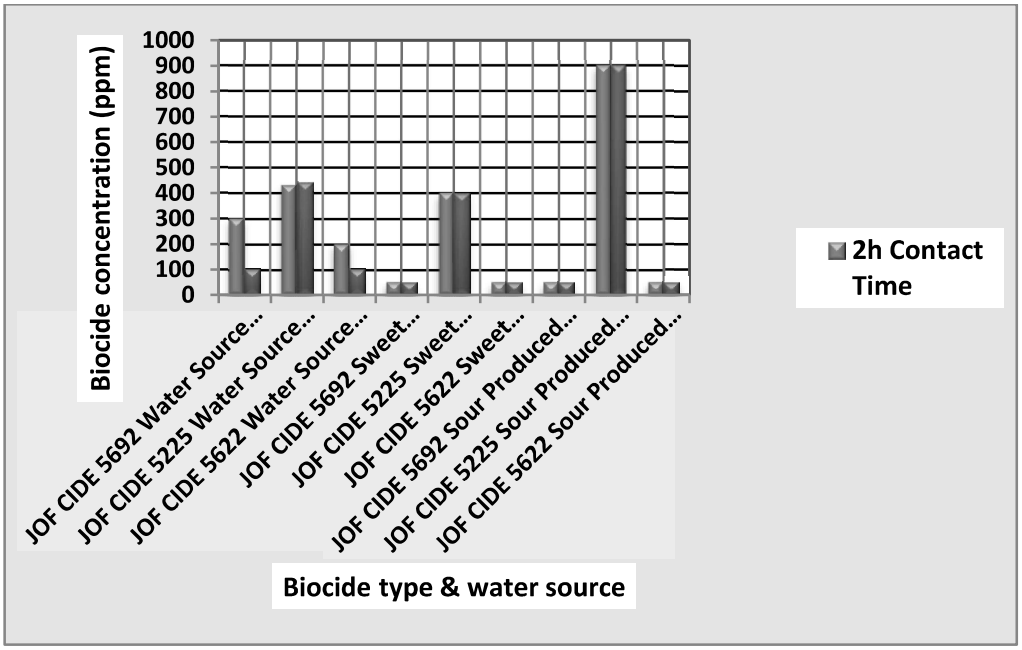
**References**

Fig. 7 MIC of biocide chemicals for SRB in Sweet Produced Water

JOF CIDE 5622 (phosphonium based biocide) is the most effective biocide among the three products studied in this research, because of the Minimum inhibition concentration shows the lowest values 50 ppm in both cases for 2 hours and 24 hours.

Otherwise, the Minimum inhibition concentration of JOF CIDE 5692 (glutaraldehyde based) biocide shows high values 300 ppm and 100 ppm at killing time 2 hours and 24 hours in SRB in Water from Water Source Wells respectively. Generally, we can say that it gave satisfactory results for eradication of SRB in Ghani field waters.

By comparison the results of the three different biocide in the three cases of water sources, it is obviously that the eradication SRB in Sweet Produced Water and SRB in Sour Produced Water more effective than SRB in Water from Water Source Wells, especially for JOF CIDE 5692 (Glutaraldehyde Based) and JOF CIDE 5622 (Phosphonium Based) as shown in Figure 8.



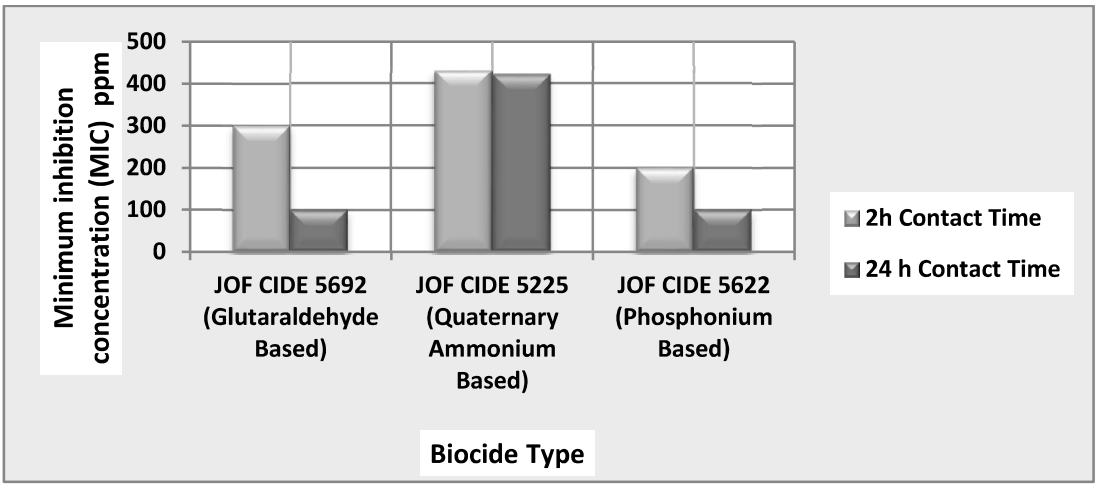



Fig. 5 MIC of biocide chemicals for SRB in Water from Water Source Wells

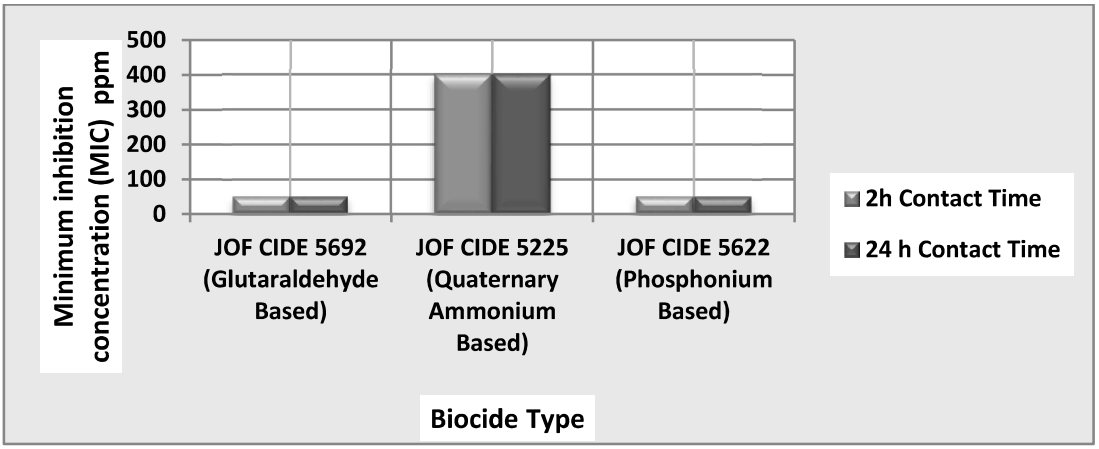
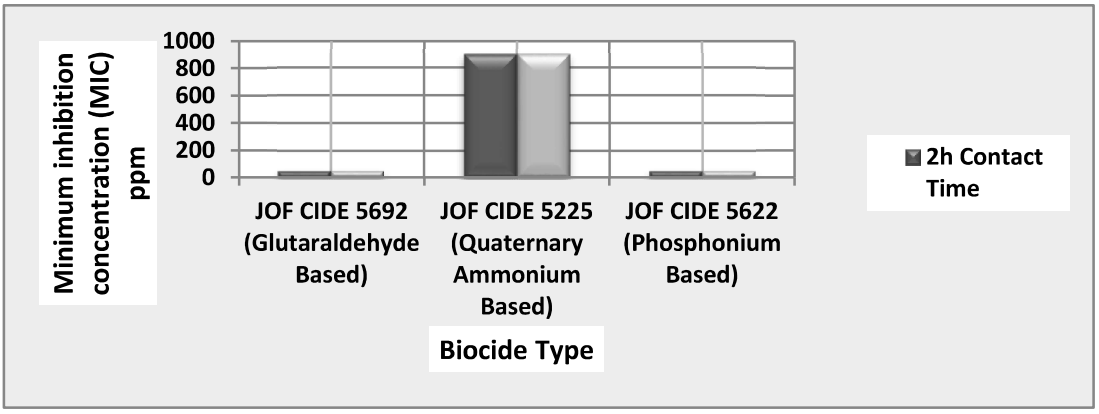



Fig. 6 MIC of biocide chemicals for SRB in Sour Produced Water



At 2 h contact time MIC value is 50 ppm ; At 24 h contact time MIC value is 50 ppm

The minimum inhibition concentration has also been calculated at 2h and 24h contact time of biocide chemicals studied in this work. The summary of results is presented in Table 10.

Table 10: Minimum inhibition concentration (MIC) of biocide chemicals at 2h and 24h contact time for killing SRB

| Biocide | MIC Value | |
|---|---|---|
| | 2h Contact Time | 24 h Contact Time |
| ***SRB in Water from Water Source Wells*** | | |
| JOF CIDE 5692 (Glutaraldehyde Based) | 300 ppm | 100 ppm |
| JOF CIDE 5225 (Quaternary Ammonium Based) | Not Effective up to 400 ppm | Not Effective up to 400 ppm |
| JOF CIDE 5622 (Phosphonium Based) | 200 ppm | 100 ppm |
| ***SRB in Sweet Produced Water*** | | |
| JOF CIDE 5692 (Glutaraldehyde Based) | 50 ppm | 50 ppm |
| JOF CIDE 5225 (Quaternary Ammonium Based) | 400 ppm | 400 ppm |
| JOF CIDE 5622 (Phosphonium Based) | 50 ppm | 50 ppm |
| ***SRB in Sour Produced Water*** | | |
| JOF CIDE 5692 (Glutaraldehyde Based) | 50 ppm | 50 ppm |
| JOF CIDE 5225 (Quaternary Ammonium Based) | 900 ppm | 900 ppm |
| JOF CIDE 5622 (Phosphonium Based) | 50 ppm | 50 ppm |

On the other hand, the obtained results are expressed graphically as shown in figures 5, 6 and 7.

The MIC values are clearly indicating that quaternary ammonium based biocide (JOF CIDE 5225) is not very effective biocide for killing SRB in the waters of Ghani oilfield. Whereas the Minimum inhibition concentration reached to 900 ppm for both 2 hours and 24 hours

| Concentration of Biocide in ppm | Control | | | Time Kill Test - 2h | | | | | | Time Kill Test – 24 h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. 1 | | | Serial No. 1 | | | Serial No. 2 | | | Serial No. 1 | | | Serial No. 2 | | |
| 50 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 100 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 200 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 300 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 400 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |

+ indicates the growth of SRB ; - indicates no growth of SRB

At 2 h and 24 h contact time 50 ppm concentration of chemical is enough to kill SRB

Table 8: Effect of JOF CIDE 5225 (Quaternary Ammonium Based Biocide) on SRB Killing Test in Sour Produced Water

| Concentration of Biocide in ppm | Control | | | Time Kill Test - 2h | | | | | | Time Kill Test – 24 h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. 1 | | | Serial No. 1 | | | Serial No. 2 | | | Serial No. 1 | | | Serial No. 2 | | |
| 50 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 100 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 200 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 300 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 400 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 700 | + | + | + | + | - | - | + | - | - | - | + | - | - | - | - |
| 900 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 1000 | + | + | - | - | - | - | - | - | - | - | - | - | - | - | - |

+ indicates the growth of SRB ; - indicates no growth of SRB

The chemical is effective at 900 ppm concentration at 2h and 24 h contact time

Table 9: Effect of JOF CIDE 5622 (Phosphonium Based Biocide) on SRB Killing Test in
Sour Produced Water

| Concentration of Biocide in ppm | Control | | | Time Kill Test - 2h | | | | | | Time Kill Test – 24 h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. 1 | | | Serial No. 1 | | | Serial No. 2 | | | Serial No. 1 | | | Serial No. 2 | | |
| 50 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 100 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 200 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 300 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 400 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |

+ indicates the growth of SRB ; - indicates no growth of SRB

+ indicates the growth of SRB ; - indicates no growth of SRB
At 2 h and 24 h contact time 50 ppm concentration of chemical is enough to kill SRB

Table 5: Effect of JOF CIDE 5225 (Quaternary Ammonium Based Biocide) on SRB
Killing Test in Sweet Produced Water

| Concentration of Biocide in ppm | Control | | | Time Kill Test - 2h | | | | | | Time Kill Test – 24 h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. 1 | | | Serial No. 1 | | | Serial No. 2 | | | Serial No. 1 | | | Serial No. 2 | | |
| 50 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 100 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 200 | + | + | + | + | - | - | + | + | + | + | + | + | + | + | - |
| 300 | + | + | + | + | + | + | - | - | - | + | - | - | + | + | + |
| 400 | + | + | + | - | + | - | + | + | - | + | + | - | + | + | - |

+ indicates the growth of SRB ; - indicates no growth of SRB
The chemical is not effective to kill SRB at 400 ppm concentration.

Table 6: Effect of JOF CIDE 5622 (Phosphonium Based Biocide) on SRB Killing Test in
Sweet Produced Water

| Concentration of Biocide in ppm | Control | | | Time Kill Test - 2h | | | | | | Time Kill Test – 24 h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. 1 | | | Serial No. 1 | | | Serial No. 2 | | | Serial No. 1 | | | Serial No. 2 | | |
| 50 | + | + | + | + | - | - | + | - | - | - | - | - | - | - | - |
| 100 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 200 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 300 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 400 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |

+ indicates the growth of SRB ; - indicates no growth of SRB
At 2 h contact time MIC value is 100 ppm ; At 24 h contact time MIC value is 100 ppm

Table 7: Effect of JOF CIDE 5692 (Glutaradehyde Based Biocide) on SRB Killing Test in Sour Produced Water

| Concentration of Biocide in ppm | Control | | | Time Kill Test - 2h | | | | | | Time Kill Test – 24 h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. 1 | | | Serial No. 1 | | | Serial No. 2 | | | Serial No. 1 | | | Serial No. 2 | | |
| 50 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 100 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 200 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 300 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 400 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

+ indicates the growth of SRB ; - indicates no growth of SRB

The chemical is not effective to kill SRB at 400 ppm concentration of above mentioned chemical.

Table 3: Effect of JOF CIDE 5622 (Phosphonium Based Biocide) on SRB Killing

Test in Water from Water Source Wells

| Concentration of Biocide in ppm | Control | | | Time Kill Test - 2h | | | | | | Time Kill Test – 24 h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. 1 | | | Serial No. 1 | | | Serial No. 2 | | | Serial No. 1 | | | Serial No. 2 | | |
| 50 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | - |
| 100 | + | + | + | - | + | - | - | - | - | - | - | - | - | - | - |
| 200 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 300 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 400 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |

+ indicates the growth of SRB ; - indicates no growth of SRB

At 2 h contact time MIC value is 200 ppm ; At 24 h contact time MIC value is 100 ppm

Table 4: Effect of JOF CIDE 5692 (Glutaradehyde Based Biocide) on SRB Killing

Test in Sweet Produced Water

| Concentration of Biocide in ppm | Control | | | Time Kill Test - 2h | | | | | | Time Kill Test – 24 h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. 1 | | | Serial No. 1 | | | Serial No. 2 | | | Serial No. 1 | | | Serial No. 2 | | |
| 50 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 100 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 200 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 300 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 400 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |

In the present study the following concentrations of biocides were used:

a) **For JOF CIDE 5692:** Control (zero concentration), 50 ppm, 100 ppm, 200 ppm, 300 ppm, and 400 ppm.
b) **For JOF CIDE 5225:** Control (zero concentration), 50 ppm, 100 ppm, 200 ppm, 300 ppm, and 400 ppm, and 700, 900 and 1000 ppm in case of quaternary ammonium based biocide on SRB Killing Test in Sour Produced Water.
c) **For JOF CIDE 5622:** Control (zero concentration), 50 ppm, 100 ppm, 200 ppm, 300 ppm, and 400 ppm.

In all cases triplicate results were obtained by using tubes containing media in three bottles. Control samples were also in triplicate. The contact time was selected as 2 hours and 24 hours. The period of all tests were carried out through 28 days. The summary of results for all tests are presented in Tables from 1 to 9.

Table 1: Effect of JOF CIDE 5692 (Glutaradehyde Based Biocide) on SRB Killing
Test in Water from Water Source Wells

| Concentration of Biocide in ppm | Control | | | Time Kill Test - 2h | | | | | | Time Kill Test – 24 h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Serial No. 1 | | | Serial No. 1 | | | Serial No. 2 | | | Serial No. 1 | | | Serial No. 2 | | |
| 50 | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 100 | + | + | + | + | + | + | + | + | + | - | - | - | - | - | - |
| 200 | + | + | + | - | + | + | + | + | - | - | - | - | - | - | - |
| 300 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |
| 400 | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - |

+ indicates the growth of SRB; - indicates no growth of SRB
At 2 h contact time MIC value is 300 ppm ; At 24 h contact time MIC value is 100 ppm

Table 2: Effect of JOF CIDE 5225 (Quaternary Ammonium Based Biocide) on SRB Killing Test in Water from Water Source Wells

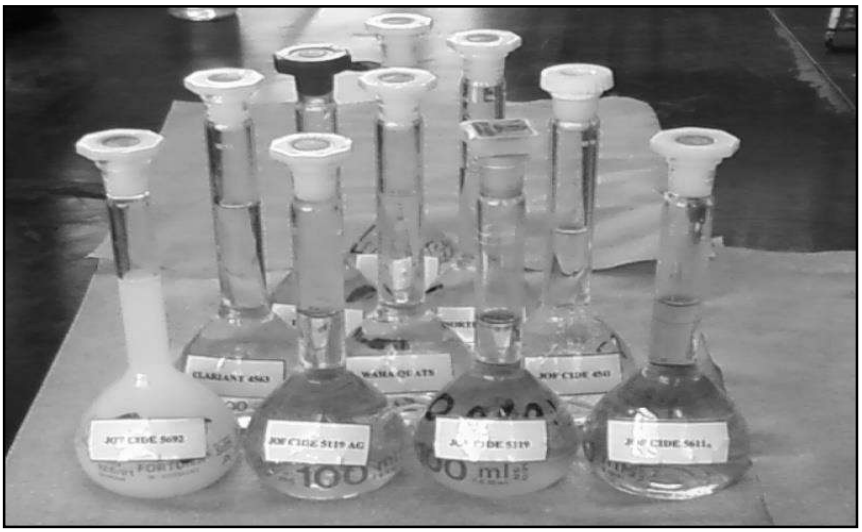


Fig. 4 Different kind of biocide chemicals

**9.1. JOF CIDE 5692:**It is an aldehyde based bactericide formulated for use in water flood or waste water disposal systems. It contains 50% glutaraldehyde as an active ingredient.

**9.2. JOF CIDE 5225:** It is contains a quaternary ammonium compound which has been shown to be effective against the bacterium Legionella Pneumophilia under specific conditions of dosage and contact time.

**9.3. JOF CIDE 5622:** It is an aqueous solution of quaternary phosphonium based compounds. JOF CIDE 5622 is designed to control and kill aerobic and anaerobic sulfate reducing bacteria usually encountered in oilfield systems.

The time-kill test procedure was followed to determine the minimum concentration of chemical (MIC) required to kill sulphate reducing bacteria in the infected water. Injection waters known to be infected with sulphate reducing bacteria are exposed to different concentrations of the chemical under consideration. At specific time intervals, aliquots were removed and placed in tubes of sulphate reducer medium.

treatment before utilizing as injection water for enhanced oil recovery or disposed into the open pit.

### 8.4. Types of Biocides Used

The following three different class of biocide products are used in this study can be illustrated as following:

**8.4.1. Jofcide 5692:** Glutaraldehyde based biocide (Jowfe Oil Technology Company Product ) .

**8.4.2.Jofcide5225**: Quaternary ammonium based biocide (Jowfe Oil Technology Company Product).

**8.4.3. Jofcide5622** : Phosphoniumsulphate based biocide (Jowfe Oil Technology Company Product).

However, Figure 4 exhibits the different kind of biocide chemicals that have been used in the investigation study.

### 9. Results and Discussion

The results of the experimental work that have been carried out on Ghani oilfield for studying the problems and method of eradication sulfate reducing bacteria (SRB) in the light of different parameters e.g. biocide type, water source, concentration of biocide and incubation periods. As it is mentioned earlier that Ghani oilfield contains sweet and sour crudes. Therefore, the produced water obtained by separation of sweet crude and the produced water obtained from the sour crude were studied for the presence of sulfate reducing bacteria and their eradication by using chemicals called biocides. The water from water source wells has also been evaluated for the presence and eradication of sulfate reducing bacteria. Three different formulations of biocide products were used in this study including:

class of biocide are used to eradicate with SRB and also not developing immunization of the chemical with microbes. The schematic diagram is shown in Figure 3.

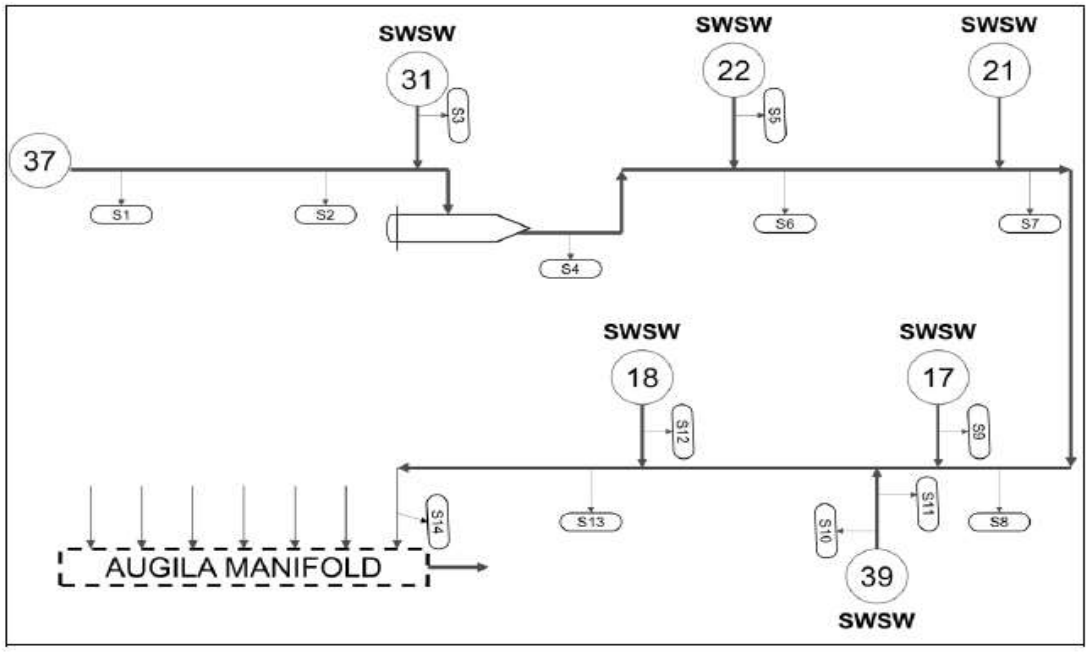



Fig. 3 Water sources wells flow line L5 configuration

### 8.3.2. Sweet produced water

Crude oil is produced as an emulsion of crude oil, water and gases. During production, this emulsion is goes to separators to yield a crude oil, water and gases. The separated water is called produced water. The produced water from Farrud formation is free of sulfide sour and hence called sweet produced water. This water has been treated for microbial treatment before utilizing as injection water for enhanced oil recovery or disposed into the open pit.

### 8.3.3. Sour produced water

The produced water from Gir formation is a sour water since it contains dissolved hydrogen sulfide ($H_2S$) which is given name as sour produced water. This water has been treated for microbial

Normally only 30% of the oil in a reservoir can be extracted, but water injection increases that percentage (known as the recovery factor) and maintains the production rate of a reservoir over a longer period.

Fig. 2 Farrud main injection station

### 8.3. Types of Water Used for Study

The following three different types of water were selected for this study.

#### 8.3.1. Water source wells

Ghani field has 41 water source wells. The water was collected from water source wells at seven wellhead namely SWSW 17, SWSW 18, SWSW 21, SWSW 22, SWSW 31, SWSW 37, and SWSW 39. All the station collected in Augila Manifold and then to Farrud and Zenad water injection plants . This water has been treated for microbial treatment to eradicate the water with sulphate reducing bacteria (SRB) by using biocide chemicals. Generally two different

Fig. 1 Diagram of injection project (wells and plants) in Ghani field.

Corrosion : injected to reduce suspended result in corrosion. pH of water over 7.00, and oxygen content 0.00.

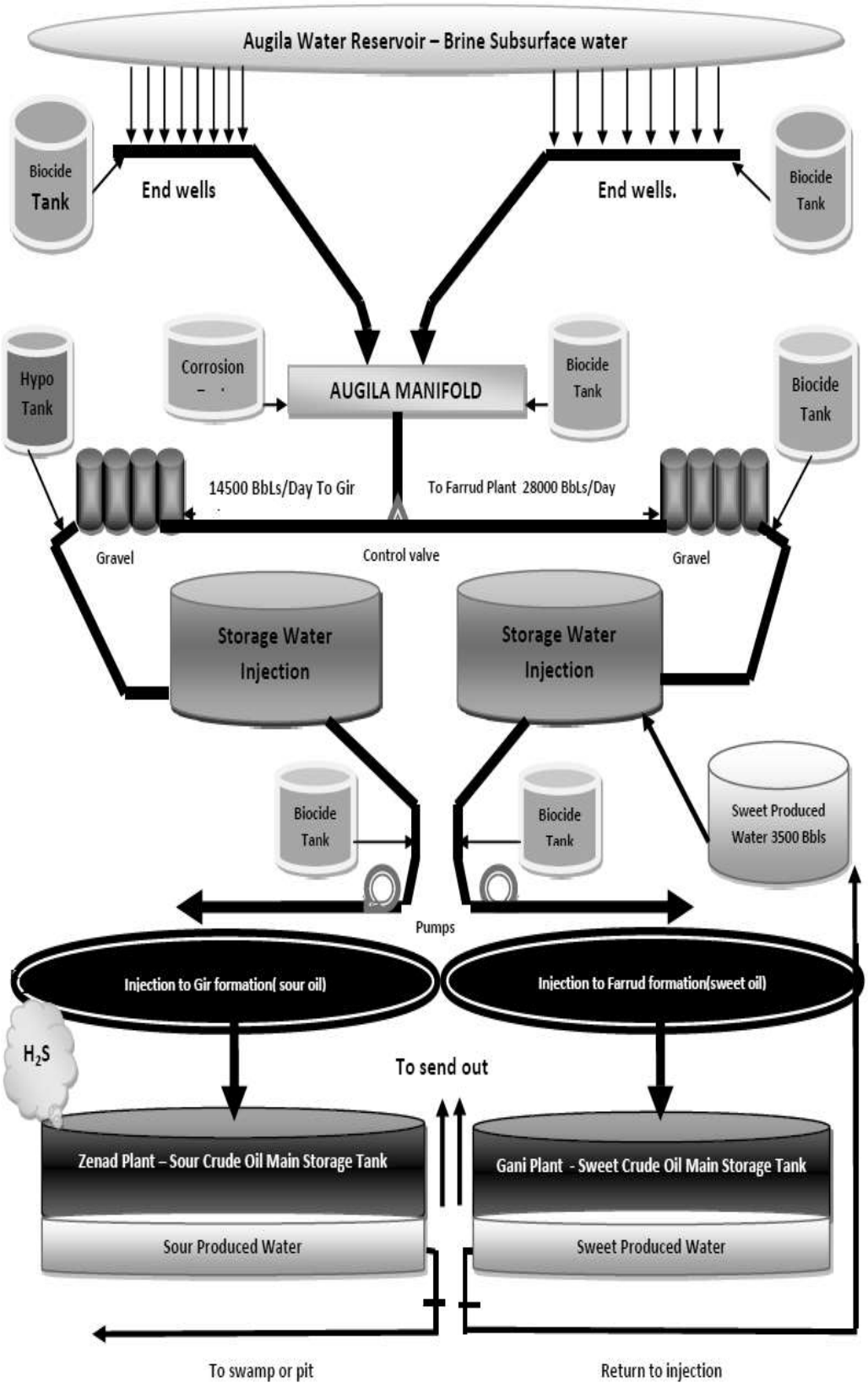
Sodium Hypochlorite: injected to precipitate suspended iron due to plugging wellbore

The Ghani main station is a sweet oil processing facility consisting of separation, treating, desalting, storage and shipping. The nominal capacity of the station is 74,000 barrels of oil per day. The sour crude processing facilities are located in Zenad, just north of the Ghani Field, where all sour crude produced in Ghani, Ed Dib and smaller fields is gathered and processed before it is blended with Ghani's sweet crude for export to RasLanuf Terminal. In Ghani, facilities are also available for producing diesel fuel, dry fuel gas, potable water treatment and power generation. In recent years, two water injection projects were completed for pressure maintenance in the Farrud and the Gir reservoirs. The injection water is derived from a saline water source just west of the Ghani Field. Also, all the water produced together with the Farrud crude oil is re-injected. Both water streams are conditioned in a water treatment plant prior to (re-)injection ensuring high water quality. Figure 2 shows Farrud main injection station.

## 8.2.Water injection

Water injection refers to the method in the oil industry where water is injected into the reservoir, usually to increase pressure and thereby stimulate production. Water injection wells can be found both on- and offshore, to increase oil recovery from an existing reservoir. Water is injected

1- To support pressure of the reservoir (also known as voidage replacement)
2- To sweep or displace oil from the reservoir, and push it towards a well.


Augila Water Reservoir – Brine Subsurface water
Biocide Tank
End wells
End wells.
Biocide Tank
Hypo Tank
Corrosion
AUGILA MANIFOLD
Biocide Tank
Biocide Tank
14500 BbLs/Day To Gir
To Farrud Plant 28000 BbLs/Day
Gravel
Control valve
Gravel
Storage Water Injection
Storage Water Injection
Biocide Tank
Biocide Tank
Sweet Produced Water 3500 Bbls
Pumps
Injection to Gir formation( sour oil)
Injection to Farrud formation(sweet oil)
$H_2S$
To send out
Zenad Plant – Sour Crude Oil Main Storage Tank
Gani Plant - Sweet Crude Oil Main Storage Tank
Sour Produced Water
Sweet Produced Water
To swamp or pit
Return to injection

SRB are often thought to be strictly anaerobic, however, some genera can still grow well at low dissolved oxygen concentrations.The factors that could affect SRB behavior and resultant corrosion of mild steel include nutrient availability, temperature, sulfide inhibition and adhesion of cells to the metal surfaces(11,12)

## 8..Material and Methods

### .8.1Location of Study

Ghani Field has been selected as field location of this study. Ghani field belongs to Waha Oil Company which is one of the subsidiaries company of National Oil Corporation of Libya. The Ghani Field was discovered in 1972 in the western Sirte Basin. The GhaniFarrud sweet oil reservoir was discovered in January 1978, while the Ghani main station was built and commissioned in 1980. The main reservoirs include the Farrud (sweet crude) and the Gir/Facha reservoirs (sour crude). The Ed Dib Field is located just east of the Ghani Field and offers significant (sour crude) development potential. Figure 1 shows a diagram of injection project (wells and plants) in Ghani field.

accelerate metal corrosion has attracted many investigators, but details of the process are still inadequately understood(6)

## 5.Microbiologically Influenced Corrosion (MIC)

MIC can be defined as corrosion initiated or accelerated by microorganisms(9). MIC is also known as biological corrosion , biologically influenced corrosion, biologically induced corrosion , microbial corrosion , microbiologically induced corrosion and biocorrosion.

## 6.General Characteristics of MIC

In principle, corrosion is an interfacial process and the electrochemical mechanisms remain valid for MIC. However, the presence of microorganisms growing at interfaces can influence not only the anodic and cathodic reactions, but also such interfacial properties as pH value, salts, redox potential and conductivity. These organisms could adhere to the available surfaces, enclose themselves in sticky extracellular polymeric substances (EPS) and form biofilms .

The mechanisms interpreted the whole corrosion process with microbial participation, but the modification of the interface structure due to biofilm accumulation should be regarded as the main cause of MIC(8 )

## 7.Sulfate Reducing Bacteria

Sulfate-reducing bacteriaare a group of specialized microorganisms that occur in aqueous environments in the absence of oxygen. In a sense, these organisms "breathe" sulfate rather than oxygen, in a form of anaerobic respiration(10.(

## 2 .Aerobic Microbial Corrosion

Aerobic microbial corrosion involves complex chemical and microbial processes due to metabolic activities of different groups of microorganisms, Usually, even in aerobic corrosion, oxygen concentration may be very low, for instance underneath microbial colonies or biofilms (7). The anodic dissolution of Fe to Fe+2 preferentially takes place at such micro-oxic to anoxic sites, whereas electrons flow to the other sites, where they can reduce molecular oxygen(3). The Fe+2 formed may be oxidized chemically or by iron-oxidizing bacteria to hydrates of ferric oxides that are deposited as rust on the metal surface(1). Pseudomonas species and other slime-forming bacteria are commonly found in connection with corrosion.They colonize the metal surface, thereby creating oxygen-free environments for anaerobic bacteria, especially sulfate reducers(8.(

## 4.Anaerobic Microbial Corrosion

Iron and iron alloys also corrode severely in oxygen-free environment pipelines, offshore oil platforms and underground structures have been reported to be quite vulnerable to biological corrosion which is assumed to be mediated by different groups of microorganisms respiring with oxidized compounds such as sulfate, nitrate, ferric iron or carbon dioxide(3,4.(

## 5.Anaerobic Corrosion By Sulfate Reducing Bacteria

Sulfate-reducing bacteria are proposed to be chiefly responsible for anaerobic corrosion, particularly in environments with high sulfate concentrations such as seawater. From a scientific point of view, the mechanistic aspects of the interaction between these organisms and iron are of special interest. The mechanism by which sulfate reducers

economic damages and is, therefore, of great concern. According to recent investigations, damages due to material corrosion in the United states cause annual costs of 276 X 109 U.S. $ in many fields of industry. Other studies undertaken in several countries including the United Kingdom, Japan, Germany, Sweden and Australia revealed that the annual costs due to corrosion damages ranged from 1 to 50 % of the gross national product (GNP) of each nation(2.(

If a metal comes into contact with water , positive metal ions are released into the solutions and leave free electrons on the metal:

**Me ↔ Me+2 + 2e-**

The reaction shifts to the right if the liberated electrons are continuously removed, resulting in a net dissolution of the metal. Free electrons cannot be released as such into the medium; usually they can be consumed by reactions with oxidizing substances from the aqueous phase at the metal-water boundary. Such electron acceptors might be oxygen, protons, undissociated weak acids or water(1). Areas on the metal where metal dissolution or electron uptake reactions occur are termed anodic and cathodic sites, respectively. The accumulation of products of the cathodic and anodic reactions at the metal-water interface tends to slow down the rate of corrosion .

Microorganisms are able to depolarize both cathodic and anodic sites either directly by their metabolic activities or indirectly by excretion of chemically reactive products(3,4). Such microorganisms are particularly corrosive as they grow in colonies or films attached to iron surface and thereby create local electrochemical cells with highly stimulated reactions. As a result, corrosion by microorganisms often occurs as pitting, which is usually more severe than corrosion processes that are evenly distributed over the metal surface (5,6.(

التركيزات المنخفضة. فضلاً عن أنه يسبب مشاكل التآكل في منشآت إنتاج ومعالجة النفط والغاز، كما أن وجوده في النفط الخام يؤدي إلى تآكل أنابيب خطوط النقل.

وهدفت هذه الدراسة إلى إمكانية التخلص من هذه البكتيريا من مياه حقل الغاني النفطي باستخدام Biocide) chemicals والمُمثلة بثلاثة أنواع هي JOF : CIDE JOF CIDE 5225 ،5692 (glutaraldehyde based chemical) و JOF CIDE 5622 (quaternary ammonium based chemical) (phosphonium based chemical) والتي يتم الحصول عليها من شركة الجوف لتقنيات النفط .Jowfe Oil Technology Company وتم استخدام طريقة زمن القتل(Time kill method) لتعيين أدنى قيمة لتركيز تثبيط البكتيريا Minimum inhibition concentration (MIC) . ولقد أسفرت النتائج المُتحصل عليها خلال هذه الدراسة أن أفضل أداء لهذه المواد الكيميائية تمثل في النوع5622 CIDE |(JOF ، )في حين أظهرت الدراسة باستخدام النوع JOF CIDE 5692) (نتائج مُرضية، إلا أن النوع الثالث (JOF CIDE 5225لم يكن فاعلاً في التخلص من البكتيريا (SRB) في حقل الغاني.

**الكلمات الدالة** : حقل الغاني النفطي، التآكل، البكتيريا المختزلة،السلفايت، المواد الكيميائية، زمن القتل، التخلص من البكتيريا .

## 1Introduction

Iron as a base metal is usually unstable without protection and easily undergoes corrosion in aqueous environments. Corrosion has been defined as destructive attack of a metal by chemical or electrochemical reactions(1). In aqueous environments, iron materials are corroded not only by purely chemical or electrochemical reactions but also by metabolic activities of microorganisms in a process termed microbially influenced (or induced) corrosion (MIC). Corrosion of iron materials causes vast

*JOF CIDE 5225 (quaternary ammonium based chemical), and JOF CIDE 5622 (phosphonium based chemical) were obtained from Jowfe Oil Technology Company and evaluated for their biocide killing performance. The time kill method was used for determining minimum inhibition concentration (MIC) value. From the results obtained, the best performance showed by JOF CIDE 5622. JOF CIDE 5692 also showed satisfactory performance but JOF CIDE 5225 was not performed well for eradication of SRB in Ghani field.*

***Key words***
*Ghani oilfield, corrosion, Sulfate reducing bacteria, biocide chemicals, eradicated, minimum inhibition concentration (MIC), time kill method.*

## الملخص

تناولت هذه الدراسة جانباً من المشاكل الهندسية الناجمة عن البكتريا المختزلة للسلفات (Sulphate reducing bacteria (SRB في المياه المنُتجة من حقل الغاني النفطي، حيث يضم هذا الحقل مكمنين هما فرود ذات الخام النفطي الحلو وجير/فاتاشا ذات الخام المُر. كما يقع حقل الديب النفطي مباشرة شرق الغاني ذات النفط الخام المر، ويتم معالجة النفط المر في المنشآت الواقعة في زيناد شمال حقل الغاني حيث يتم تجميع النفط الخام المر من كل من حقلي الغاني والديب والحقول الصغرى الأخرى للمعالجة قبل مزجها بخام الغاني الحلو للتصدير عبر ميناء رأس لانوف.

في السنوات الأخيرة تم استكمال مشروعين لحقن الماء للحفاظ على معدل الضغط في كلٍ من مكمني فرود والجير. وتُستمد مياه الحقن من الماء المالح(الأُجاج) من غرب حقل الغاني، حيث يوجد ثلاثة أنواع مختلفة من المياه الملوثة بالبكتيريا المُختزلة للسلفات، والتي تعمل على اختزال أيون السلفات ($SO_4^{2-}$) مما يُشكل كبريتيد الهيدروجين ($H_2S$). ومن المعروف جيداً أن هذا الغاز ذو سُمية، كما يتميز برائحة البيض الفاسد حتى عند

# DETECTION AND INFLUENCE ASSESSMENT OF SULFATE REDUCING BACTERIA

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## Abstract

*The present study is related to the environmental and engineering problems caused due to the presence of sulfate reducing bacteria in produced water of Ghani oilfield. Ghani oilfield has two reservoirs namely Farrud (sweet crude) and the Gir/Fatcha (sour crude). The Ed Dib Field is located just east of the Ghani Field and offers significant (sour crude) development potential. The sour crude processing facilities are located in Zenad, just north of the Ghani Field, where all sour crude produced in Ghani, Ed Dib and smaller fields is gathered and processed before it is blended with Ghani's sweet crude for export through RasLanuf Terminal. In recent years, two water injection projects were completed for pressure maintenance in the Farrud and the Gir reservoirs. The injection water is derived from a saline water source just west of the Ghani Field. In overall Ghani oilfield has three different kind of water. The water samples from these locations were found to be contaminated with sulfate reducing bacteria.*

*The sulfate reducing bacteria can be eradicated from Ghani oilfield water by using biocide chemicals. Three different classes of chemicals namely JOF CIDE 5692 (glutaraldehyde based chemical),*