Petroleum Science and Engineering
2022; 6(2): 51-58
http://www.sciencepublishinggroup.com/j/pse
doi: 10.11648/j.pse.20220602.12
ISSN: 2640-4486 (Print); ISSN: 2640-4516 (Online)

Monitoring the Water Content in Crude Oil and Determining Its Causes and Methods of Treatment

Abbas Kadhim Ayyed

Basra Oil Company, Basra, Iraq

Email address:
abbasaiad@yahoo.com

To cite this article:
Abbas Kadhim Ayyed. Monitoring the Water Content in Crude Oil and Determining Its Causes and Methods of Treatment. *Petroleum Science and Engineering*. Vol. 6, No. 2, 2022, pp. 51-58. doi: 10.11648/j.pse.20220602.12

Received: July 18, 2022; **Accepted**: August 19, 2022; **Published**: August 31, 2022

Abstract: The idea of the research is to show the effect of the Oil degrading bacteria of petroleum compounds and their transformation into final products (carbon dioxide and water) and their contribution to the formation of oil emulsions and increasing the water content in crude oil. The aim of the research was to shed light on the problem of increasing the water content in crude oil the permissible limits and the continuation of this increase even when the oil shipments reach to the customer. The research adopted the investigation and diagnosis of the vital causes expected to appear, and through the results of the laboratory examination of crude oil samples taken from oil isolation stations (production) and PS1 depot. The results showed the monitoring of specific types of bacteria that degrading hydrocarbon compounds. Two types of bacteria were identified and isolated (Pseudomonas, Actinomyces) and according to the available environmental conditions variables (moisture, mineral salts, temperature) as catalysts to increase the rate of hydrocarbon consumption by microorganisms. This is known as Biodegradation. The comparison method was adopted for both types of bacteria for the purpose of obtaining the efficiency of consumption (analysis hydrocarbon compounds) by calculating the amount of water produced by these two types of bacteria, while maintaining a control model of crude oil to which Biocide was added. The results of bacterial isolates for both types showed their ability to consume hydrocarbons. The results of the tests showed the absence of any bacterial growth in it and the absence of any increase in the water content, while the results of the tests for most sample showed positive results with oil contamination by both types bacteria. Pseudomonas bacteria gave a higher consumption rate than Actinomyces bacteria, and consequently a more increase in the percentage of water content. In addition to the increase the water content, there are other damages to the specifications of crude oil, represented by a decrease in the density of crude oil (API) due to microbial decomposition. In light of the obtained data, we concluded that the increase in the water content of the oil was the result of the presence of bacteria that degrade the oil, and the evidence for it is that the unpolluted oils did not have any change or increase in the water content.

Keywords: Biodegradation, API, Water Content, Biocide, Pseudomonas, Actinomyces

1. Introduction

Different microorganisms are characterized by the diversity of their vital activities in the field of environment, industry and other fields. It could constitute a turning point in determining the course of determining the problems arising in the oil industry. Researchers have noticed the ability of some species of microorganisms to analyze the hydrocarbon compounds that utilize oil, as sources of carbon to energy for their growth, which results in simple components up to carbon dioxide and water. There are many studies that have been concerned the oil degrading bacteria, and As it is known oil oxidizers bacteria, and when there are some of these microorganisms they adapt by their own enzymatic system and their large surface area despite their small surface area. These facts confirm the metabolic activities of the bacteria that petroleum hydrocarbons degrading by consuming and representing these compounds as they use them as the only source of carbon and energy by adapting themselves to be able to benefit from these compounds by producing the enzymes involved in the decomposition process, and selection the selective growth of the Analyses isolates at the expense of the unanalyzed isolates of oil. Many different genera of petroleum hydrocarbons decomposition, bacteria

have been identified in aquatic environments with very high salinity. There is a clear discrepancy in the ability of different types of bacteria to petroleum hydrocarbons degradation. Some of the bacteria can degradation a wide range of these compounds, while others determine their ability to degradation a number of compounds. The type of enzyme excrete by bacteria affects the ability to decomposition. The ability to decomposition ordinary alkanes containing atoms is distributed. Carbon between (10-18) atoms.

Recently, the problem of an increase the water content in crude oil has emerged, and this is considered one of the serious problems affecting the price of exported oil, as well as anther negative effects of the water formed in the oil for its role in causing corrosion. As it is known, the crude oil is located in the reservoirs adjacent to the reservoir water or overlapping with the injection water used to return the reservoir pressure again to its previous state in a phase called secondary production to maintain the production of crude oil, and thus water can be Passes in to the crude oil during the process Production or during the process of removing salts in units for removing salts from produced water.

Therefore, the flow of water with producing oil can be mix, forming oil emulsions. In water injection operations, large quantities of water are used, which is an ideal environment for the spread of microorganisms. If we assume the influence of bacterial species that decomposition oils to water, this means the start of the analyses process of hydrocarbon compounds and the formation of oil emulsions that represent the water content in oil when it is deposited.

2. How Does Salt Water Mix with Crude Oil

Salt water spreads in crude oil in two ways:

2.1. Free Water

The water spreads in the form of large particles of water inside the crude oil, and separates from the oil easily due to the density difference, once the mixture is stable for an appropriate period.

2.2. Emulsified Water

As the water spreads inside the oil in the form of droplets surrounded by a strong membrane by the action of emulsifying agents, this type of water cannot be separated easily.

3. What Is Emulsification and What Are Emulsions

Emulsification: It is the presence of two liquids that do not dissolve in each other, but rather disperse one into the other. The degree of stability of the emulsion depends on the nature of the mixture and on the nature of the two liquids as well as chemical composition (viscosity, and temperature) has an effect on the stability of emulsions and for an emulsion to form, two liquids must be available, one of which does not mix with The other with the presence of emulsifying agents and sufficient mixing time for the dispersion of the in the continuous phase. In the petroleum industry, oil and water are liquids that do not mix with each other, and the emulsifying agent is solid particles.

Paraffins, Asphaltens, soluble organic acids in oil, resinous substances, in addition to solid substances dispersed in oil such as sand, carbon, calcium, silica, iron, zinc, aluminum sulfate, while mixing takes place in wells, pipes and in Choke valves [4].

3.1. Factors for Different Thicknesses of the Emulsion Layer Components for Several Reasons

1. The amount of emulsifying substances present in the crude oil.
2. Solid impurities present in crude oil or water.
3. The degree of emulsification of water in crude oil.
4. Waxy components in crude oil.

The difficulty of separating the emulsified water depends on the stability of this emulsion, on the following factors:

1. Density difference between water and oil.
2. The size of the water molecules.
3. Viscosity.
4. Interfacial Tension.
5. Presence of emulsifying agents.

Density difference we consider one of the most important factors that determine the speed of descent of water droplets from the continuous phase of the oil. As the greater the difference between the two densities, the less the stability of the emulsion and the faster the descent and the stability of the water droplets, formation, the water content".

The size of the drop contributes to the speed of its descent, as the greater its size, the faster its stability and descent in the continuous phase. The size of the emulsion drop depends mainly on the degree of mixing to which the emulsion is exposed before treatment, since the flow is through pumps, throttles, other valves or some equipment.

3.2. Microbiological Biodegradation of Crude Oil Components

Biodegradation of crude oil occurs in the contact area between crude oil and water, which leads to the exposure of alkanes and alkanes to degradation in this area and the flow of products of this reaction in the opposite direction to the flow of oil unchanged also occurs in this area, a typical feature is the removal of alkanes, followed by hydrocarbons and increases The rate of biodegradation is nature's way of recycling wastes, or decomposition organic matter into nutrients that can be used by other organisms. "Degradation" means decay, a wide variety of bacteria have been isolate from or have been detected in oil field sample by molecular techniques, aerobic, factitively anaerobic [2]. widespread at high temperatures inside conveyor Pipe line or tanks. The effect of biodegradation on the components of crude oil is

shown by the size and concentration of microorganisms in the reaction area. In the event that crude oil is more degradable by living organisms, a difference in the oil content occurs and a change in a large number of hydrocarbon rings is inversely proportional to the rate of biological decomposition [10]. Light crude oil undergoes bio degradation faster than Heavy crude oil This difference in the rate of degradation is likely because light compounds have a very high percentage in light oil compared with to heavy oil, as heavy oil compounds are characterized by the components of tar balls, which are characterized by their sulfur components. As for compounds with double bonding (alkenes), their exposure to degradation is less than that of ordinary alkanes. This indicates that the formation of oil is the main factor influencing the increase in the decomposition of crude oil, and it was observed that the biodegradation of cyclic compounds can be oxidized by bacteria, and Studies have shown that compounds with straight chains are more exposed compared to compounds with branched chains, and that the ability of bacteria to degradation decreases with increasing branching chain length and number of branches Hence the indicators of the decomposition of crude oil It may be affected in general by its components in addition to the type of biodegradation of the original bacteria in the analysis of light hydrocarbons also can happen under biodegraded anaerobic conditions for crude oil in oil reservoirs. The bacteria are highly selective for metabolism [3].

3.3. Mechanism Biodegradation of Hydrocarbon Oils

One of the risks of vital activity is the analysis of petroleum hydrocarbon compounds during the production process and the basic factors that affect the analysis of oil compounds, which results in multiple effects that affect the quality of crude oil, biodegradable at ambient temperature, in some cases low bio availabilities are the reason for slow biodegradation. Considerably higher mass transfer rates and polycyclic aromatic hydrocarbon (PAH) solubilities and hence bio availabilities can be obtained at higher temperatures [11]. including the increase in water content because bacteria uses these hydrocarbon compounds as a source of carbon and energy, and that the final of the result (carbon dioxide) The process begins with the oxidation of alkanes to alcohols to aldehydes and then to fatty acids and continues by converting intermediate compounds into water and releasing carbon dioxide, and here these products can be the additives that lead to an increase in the water content.

3.4. Biodegradation Advantage in Aerobic Condition

Many soil microorganisms (such as bacteria and fungi) convert petroleum hydrocarbons into non-toxic compounds or completely mineralize inorganic compounds and return them to nature as harmless elements to the environment. Therefore, this natural microbial activity is used in biological treatment to reduce the concentration of various pollutants, including crude oil. Thermophilic bacterial isolates utilized crude oil as carbon source with an increase in growth and cell proliferation [15]. This technology is one of the latest methods used in the treatment of oil pollutants. It is better than the methods of using chemical compounds that may adversely affect the soil and cannot be used again. Most importantly, these processes are natural and the end products of the bio analysis are carbon dioxide and water that does not affect the soil. The effectiveness of bio analysis depends on the number of carbon atoms as a source of energy under aerobic conditions by living organisms [12].

3.5. Work Materials and Methods

Laboratory equipment and materials used:

1. Incubator
2. Shaker Incubator
3. Autoclave
4. Water cut
5. Nutrient media to isolate bacteria, which is:

Nutrient agar
Pseudomonas agar
Actinomyces agar

3.6. The Steps Involved in Completing the Research Include Six Stages, as Follows

First/ a comprehensive survey of production stations and all oil sites:

Samples were collected from crude oil to verify the presence of emulsified water within the operations of the Basra Oil Company in North and South Rumaila, West Qurna, Zubair and Nahr bin omar, and measuring the prevailing temperatures in the samples taken locally due to the temperature correlation.

Second / to check the presence of bacteria and the amount of water in the crude oil, the following methods were used:

3.6.1. Biological Examination

This method was used to count the number of bacteria colonies on the medium of Pseudomonas agar Hydrocarbon-utilizing bacteria were isolated from oil-brine, soils etc. sampled in oil fields and the following species were identified: hydrocarbon nov.sp., 11strains; Pseudomonas strains: Brevibacterium lipolyticum strains; Pseudomonas [6].

As well as Actinomyces agar, which can be given by one ml of the crude oil sample or reservoir water, and this was done by another adding one ml of the crude oil sample or water to a nutrient medium for both of the above mediums, after which the dishes are left to be placed in the incubator for three days at a temperature of 37°C.

3.6.2. Examination of the Water Section

It is one of the ways to check the percentage of water in crude oil with the following points:

1. Withdraw the sample from the sample points, take 100 ml of the sample and place it in the water cut device, and add 100 ml of xylene to the sample.
2. Run the examination device for 45 minutes.
3. Reading the percentage of the water content coming down from the condenser to the listed trap.

4. The reading is taken as a percentage.

3.6.3. Density Measurement

The density of the oil is measured by a hydrometer and according to the quality of the oil as the hydrometer is immersed inside the sample and the density is read [5].

$$API = 141.5 - 131.5$$

4. Results and Discussion

The research adopted the investigation of the real reasons for the increase in the water content in crude oil, which were not highlighted by the competent scientific authorities and are also unknown to most staff in the oil industry. North and South Rumaila, Hammar, Zubair Mishref, Nahr Bin umar and West Qurna for production stations and Depot PS1. The results showed an impressive increase in the percentage of water content due to the presence of Oil-degrading bacteria in crude oil samples. To prove that the increase in water content occurred as a result of presence bacteria, the work included conducting chemical and biological tests in two stages:

The first stage:

the investigation of oil degrading bacteria in crude oil samples of production stations and Depot PS1, and two types of bacteria (Pseudomonas, Actinomyces) were detected, and they are among the oil degrading bacteria) shown in Table 1.

The second stage:

It included the investigation of the susceptibility of bacteria to causing an increase in water content in oil samples by verifying the role of these two types of bacteria. With a control sample to which biocide was added, Where each crude oil sample was divided into two parts, the first part includes two stages, the first is measuring the density of oil and water content ratios and determining the presence of bacteria immediately after sampling, and the second stage for the same sample after leaving it for three days without any addition and repeating the same tests for comparative purposes. The results showed an increase in the percentages of the water content causes the bacteria- presence in crude oil samples of the remaining oil after three days, as shown in Tables 2, 3.

As for the second part of the control sample, to which biocide was added and also left for three days, the comparison with the contaminated sample that was left for three days showed amazing results, namely the disappearance of bacterial growth in the biological examination and a decrease in the percentage of water content or its survival within the permissible limits, and this is a practical evidence On the ability of bacterial isolates to cause an increase in water content. The isolates of (Pseudomonas, Actinomyces) showed a different ability to analyze hydrocarbon compounds, as it was found that (Pseudomonas) bacteria were more effective than bacteria (Actinomyces) in causing an increase in water content when comparing them [8]. In light of the foregoing, the research proved the role of oil-degrading bacteria in increasing the water content in the remaining crude oil and changing its quality specifications. Note that there are groups of bacteria that Degrading other oils in many numbers, which if we suppose managed to co-exist together at the same time, this means causing more damage, noting that what has been observed is for the two types only. And the research showed the importance of using materials that prevent bacterial contamination, materials that inhibit microorganisms, as known Biocide. Which gave positive results when added to crude oil by stopping the action of microorganisms that degrading oils and it gave clear evidence through biological and chemical tests that the quality specifications of crude oil were not affected by the effects of bacterial growth. Its effects Scientific sources indicate that the microorganisms endemic to oil reservoirs can grow in a harsh environment and their ability to cause effects on their surroundings represented by crude oil as a food substance that provides them with energy by decomposition hydrocarbon compounds and as a result of which the water content increases in crude oil.

Scientific sources show that extremes of temperature or reservoir pressure are specific physical factors on some types of microorganisms, in addition to the presence of other adaptive and endemic organisms in the reservoir environment, and they have the ability to withstand exceptional conditions and the ability to change the components of the ambient in which they live and the components it contains Including crude oil. In order to identify the hydrocarbon degrading mechanism of crude oil, we have to show an important point about the formation of hydrocarbon compounds over the years that go back to (biochemical) transformations of organic materials accumulated in storage sites.

As a stage the first is to form crude oil through deposits at temperatures up to 50°C. This represents the beginning of the emergence of immature crude oil known as kerogen formed through accumulations of organic materials. Based on geochemical studies of unripe crude oil (kerogen), it has a high volume of hydrocarbons with an odd number of carbon atoms. This scientific fact has a practical meaning regarding our research on the reasons for the increase in the water content in oil and the role of microorganisms in the consumption of crude oil and its compounds as a food source for them, because it contains compounds that you consume for this purpose: porphyrins metalloporphyrins, Surygala. These compounds constitute the main of carbon, so the life activity of microorganisms is largely focused on these sections in crude oil and the other oil sections varies with different oil reservoirs and oil fields, and according to the chemical composition, it leads to an increase or decrease in the process of biodegradation [9].

Thus, the microorganisms affecting the crude oil vary in their effects according to this concept, and the microorganisms include different strains and many possibilities in determining the hydrocarbon chain that is subjected to degrading and analyzing its components and the consumption of hydrocarbons is subject to and to clarify what is happening to the crude oil during the vital hydrocarbon degrading processes that know the causative Biodegradation Incidentally, the water content increases as a result of the consumption of hydrocarbons by

microorganisms. The bio degrading process varies depending on the chemical composition of the crude oil, the classification of microorganisms and their varying abilities to consume hydrocarbon compounds such as paraffin, paraffin's cyclo, and aromatic. The normal paraffin's present in an oil mixture are more easily oxidized than iso paraffins by a wide range of microorganism groups and the velocity appears inversely proportional to the degree of branching. The oxidation of branched cyclic paraffins is easier than the oxidation of un branched paraffins, especially if the branching is a long chain.

As for the aromatic groups, they are more specific by the oxidizing microorganisms of hydrocarbons, are less attacked by the oxidizing microorganisms than while the groups of cyclic paraffins.

Then to the fatty acid, followed by additional oxidation, which results in acetic acid and other acids, Bacteria and other microbes play a profound role in the oxidation of migrating hydrocarbons. Their activities are directly or indirectly responsible for many of the diverse surface manifestations of petroleum seepage [13]. And the process of oil consumption leads to the conversion of hydrocarbon compounds into (water and carbon dioxide) [7]. This is the aim of the research in proving the emergency increase in the water content shown in Tables 2, 3. Accordingly, the increase in water content will be higher when there are more bacterial types that degrading oils [3].

The two types of bacteria referred to in the research also appeared, and accordingly, when the number of bacteria varied and increased, the water content increased with it. In contrast, bacteria free oils do not have changes in their specifications or an increase in water content. Experiments showed that Pseudomonas bacteria contribute to an increase in water content more than Actinomyces bacteria, according to the hydrocarbon chain and according to the chemical classification of oil in the percentage of water content produced from both types. The formation of oil emulsions increases if the oil is from The hydrocarbon chains are from ordinary alkanes and it increases when mixing oils in oil reservoirs, Determining whether a microorganism is autochthonous (indigenous) or allochthonous (foreign or transient) to an oil reservoir is essential before any conclusions can be made, regarding its role in the ecosystem [14] where it is more affected oxidation with branched alkanes. Heavy crude oil From by microorganism this point of view, shedding light on the biological causes gives evidence through this research that the levels of bacterial contamination in the oil samples, and for all oil sites were varied, and that the study of the physical and chemical variables of those samples was collected 49 samples of a analyzes were conducted on variety of crude oil and associated water samples and them For the purpose of studying the variables of dry and wet oil as in Tables 1, 2, 3. The analyses of these results were based on the specialized indicators of bacterial species for the samples responsible for biodegradation, which is (Bio mineralization). It converts organic matter into simpler compounds by (microorganisms) by secreting a biological surfactant outside the cell that helps in the process of biodegradation [1]. Therefore, reaching the real reasons for the formation of water in crude oil, in addition to other causes, is a new scientific base.

To develop a mechanism to monitor and identify biological causes and develop new ways to reach the main causes by building accurate information to take appropriate measures in monitoring Iraqi oil fields, and not to allow biological activity to grow by using chemical treatment (inhibitors of microorganisms) that define biocide as an important technology for treating pollution Crude oil and reservoir water.

It is a very effective technology in many international oil companies and contributes to preventing the formation of water content in oil, and it is required to be implemented in oil sites through a feasibility study before it is widely used and applied by biological specialists to determine the appropriate doses.

Table 1. *Investigate the bacteria Actinomyces Pseudomonas, which causes water content.*

No.	Location	source and type of sampling	sample Date	After sample		Water content Percentage
				Pseudomonas	Actinomyces	
1	NORTH RUMAILA PS1	crude oil	22/1/2013	+	—	0.4
2	NORTH RUMAILA PS1	Crude oil /southern Line	22/1/2013	+	—	0.1
3	NORTH RUMAILA PS1	crude Oil / Northern line	22/1/2013	+	—	0.15
4	NORTH RUMAILA	crude oil / DS2	21/2/2013	+	—	3.8
5	NORTH RUMAILA	crude oil / DS3	21/2/2013	—	+	0.05
6	NORTH RUMAILA	crude oil / DS4	21/2/2013	+	—	0.2
7	NORTH RUMAILA	crude oil / PS1	21/2/2013	+	—	0.1
8	BIN UMER	crude Oil/ Bin Umar Station	28/2/2013	+	—	0.4
9	BIN UMER	crude Oil/ Bin Umar Station	28/2/2013	—	+	3.5
10	BIN UMER	crude Oil/ Bin Umar Station	28/2/2013	+	+	0.1
11	BIN UMER	crude Oil/ Bin mar Station	28/2/2013	+	+	0.1
12	South Rumaila	crude oil /shamia	10/3/2013	+	—	0.05
13	South Rumaila	crude oil /Qurinate	10/3/2013	—	+	Nil
14	South Rumaila	crude oil /centrale	10/3/2013	—	+	Nil
15	South Rumaila	crude oil / southern	10/3/2013	+	—	0.05
16	field Zubair	crude oil /zubier meshref	11/3/2013	—	—	Nil
17	NORTH RUMAILA	crude oil / DS5	13/3/2013	—	+	0.16
18	Qurana west	crude oil / DS6	13/3/2013	—	+	0.35
19	depot- ps1	crude oil	26/3/2013	+	—	not checked

No.	Location	source and type of sampling	sample Date	After sample		Water content Percentage
				Pseudomonas	Actinomyces	
20	depot- ps1	crude oil /Southern Line	26/3/2013	+	—	not checked
21	depot- ps1	Northern line – crude oil	26/3/2013	—	+	not checked
22	meshref Hammer	crude oil /Ham mar mishrif	27/3/2013	—	+	not checked
23	depot- ps1	crude oil - PS -1	29/3/2013	+	—	not checked
24	depot- ps1	crude oil– southern Line	29/3/2013	+	—	not checked
25	South Rumaila	Crude Oil/meshref station	4/4/2013	+	+	not checked

Table 2. *Bacteriological and chemical tests to determine the proportions of associated water and the type of bacteria on a medium in crude oil Pseudomonas Agar.*

NO	Sampling Source	Type of sample	Bacteriological examination	Sampling date	Examination immediately after Sampling		
					Percentage of water in processed crude oil	API	Crude Oil Density
1	DS1	Crude Oil	+	21/12/2014	0.4%	32	0,8653
2	DS2	=	+	=	0.2%	34.2	0,8538
3	DS3	=	+	=	0.8%	32.7	0,8613
4	DS4	=	+	28/12/2014	0.5%	31	0,8707
5	DS5	=	+	=	0.29%	31.6	0,8674
6	Joint Northern Complex	=	+	28/12/2014	0.97%	31.5	0,8676
7	West Qurana Station	=	-	=	0.9%	26.99	0,8931
8	Artawi Gas Station	=	+	3/12/2015	1%	42.5	0,8129
9	West Qurana Station	=	+	=	0.9	26.99	0,8931
10	PS1	=	+	=	=	32	0,8129

Table 2. *Continued.*

NO	Sampling Source	examination after 3 days Sampling			Examination after Treatment by add (Biocide)			Bacteriological examination
		Percentage of water in processed crude oil	API	Crude Oil Density	Percentage of water in Crude Oil after treatment	API	Crude Oil Density	
1	DS1	0.6%	28.9	0.8818	0.5%	28.4	0.882	Nil
2	DS2	0.5%	34.4	0.8527	0.5%	31.6	0.8673	Nil
3	DS3	2.1%	32.7	0.8616	1%	32.7	0.8615	Nil
4	DS4	0.9%	30.9	0.8711	0.7%	28.4	0.882	Nil
5	DS5	0.4%	31.6	0.8675	0.2%	31.5	0.8706	Nil
6	Joint Northern Complex	2.1%	29.8	0.8772	0.9%	31.5	0.8676	Nil
7	West Qurana Station	1.2%	26.9	0.8933	0.9%	26.9	0.8928	Nil
8	Artawi Gas Station	1.2%	39.9	0.8251	0.4%	40.9	0.8228	Nil
9	West Qurana Station	1.2	26.9	0.8933	0.9	28.4	0.882	Nil
10	PS1	+	28.9	0.881	=	28.4	0.882	Nil

Table 3. *Bacteriological and chemical tests to determine the proportions of water and the type of bacteria on the medium of Actinomycese Agar in crude oil.*

NO	Source sampling	Type of sampling	Bacteriological examination	Sampling date	Examination immediately after Sampling		
					Percentage of water in crude oil	API	Crude Oil Density
1	DS1	crude oil	+	21/12/2014	0.5%	32	0,8653
2	DS2	=	+	=	0.5%	34.2	0,8538
3	DS3	=	+	=	1%	32.7	0,8613
4	DS4	=	+	28/12/2014	0.7%	31	0,8707
5	DS5	=	+	=	0.2%	31.6	0,8674
6	Joint Northern Complex	=	+	28/12/2014	0.9%	31.5	0,8676

Table 3. *Continued.*

NO	Source sampling	Examination after 3 days Sampling			Examination after Treatment BY add) (Biocide			
		Percentage of water in crude oil	API	Crude Oil Density	Bacteriological examination	Percentage of water in processed crude oil	API	Crude Oil Density
1	DS1	0.5%	28.9	0.8818	Nil	0.4%	28.4	0.8818
2	DS2	0.8%	34.4	0.8527	Nil	0.2%	31.3	0.8689
3	DS3	1.9%	32.7	0.8616	Nil	0.8%	32.7	0.8641
4	DS4	0.8%	30.9	0.8711	Nil	0.5%	30.9	0.8713
5	DS5	0.3%	31.6	0.8675	Nil	0.29%	31.5	0.8676
6	Joint Northern Complex	1.4%	29.8	0.8772	Nil	0.97%	29.6	0.8779

5. Conclusions

The research reached the following conclusions:

1) The research reached to identify new causes that have a role in the formation of oil emulsions and water content, which are unknown and not previously diagnosed, and they are the biological causes represented by microorganisms that degrading oils that lead to an increase in the water content in oil.
2) Experiments showed the diagnosis of two types of bacteria that consume oil, namely Pseudomonas and Actinomyces, which are groups of bacteria that degradation oil.
3) Experiments have shown that emulsions formed due to organisms that oil degrading are among the complex emulsions, as the droplets are within a size between 20-40 microns, and this requires increasing additional amounts of demulsified, which leads to additional costs in the production process.
4) In addition to the bio-formed emulsions, emulsions are formed spontaneously as a result of the turbulent movement generated by the rapid passage of oil and water through the valves and pipes used in the production of oil, and they are of the water-in-oil type.
5) As a result of the increase in oil production rates, this leads to an increase in the interaction between crude oil and reservoir water, which is one of the reasons for the increase in the quantities of water with oil.
6) The research concluded that the amount of water content in crude oil samples was high and calls for the need to form a technical committee that includes the specializations (biological, chemical, production engineers) to find out all the causes of water content and take the necessary measures for them through laboratory experiments to search for these reasons If any, and specifying the necessary treatments, whether in production operations or storage in depot or when exporting, to reduce the increase in costs and additional wages for maintenance work on production equipment to treat corrosion in oil equipment.
7) Using chemical treatment (inhibitors of microorganisms), which defines biocide, as an important technology for treating crude oil and reservoir water pollution. It is a very effective technology in many international oil companies and contributes to preventing the formation of water content in oil.

6. Recommendations

In order to counteract the increase in water content in crude oil, we recommend the following:

1) Forming a joint workshop with the production, storage Division to take a serious stand on this problem and develop possible solutions by benefiting from the results of the research, which proved the role of oil-degradation microorganisms in increasing the water content and other reasons, which requires concerted efforts to be processed. We recommend conducting a complementary study to this research on the exported oil.
2) We recommend conducting a study on the efficiency of the emulsification matter in oils contaminated with bacteria that degrading the oils. We recommend the use of biocides, as it is an important technology for treating crude oil and reservoir water pollution. These materials must be characterized by high quality specifications to be agreed upon through contracting with companies specialized in this field before they are used in production sites with other chemicals.
3) To complement the findings of the research, we recommend conducting a study on the rest of the microorganisms such as (bacteria else, fungi, algae, cyanobacteria) and studying the aerobic and anaerobic metabolic pathways responsible for the hydrocarbon consume of oil and causing the formation of emulsions, which are type (water / oil) the physical characteristics of the oil, such as viscosity, as shown by research experiments regarding the increase in water content due to biological decomposition. It is attributable to the formation of field biological monitoring units to routinely check crude oil from all production stations and to use biocide treatment when contaminated with bacteria.
4) The research recommends the selection of oil demulsifier materials in laboratory and field conditions of temperature and electric field and the combined effect of these factors to reach the best material suitable for the environmental conditions that may affect the quality of these materials [8].

We recommend intensifying the use of the following chemicals after agreement with the relevant authorities for each substance and knowing their quality in reducing the effects of poor quality water on oil equipment, and they are complementary to the fourth point from the following aspects: Microbial killers will have two role:

First: Preventing oil-degrading bacteria increasing the proportion of water.

Second: Prevent corrosive bacteria.

7. Technical and Economic Feasibility

The research proved the role of microorganisms in increasing the water content in crude oil and the importance of taking procedures to reduce the activity of bacteria that degrading crude oil, which causes changing the specifications of crude oil and increasing the water content, which is one of the serious problems that the oil sector suffers from and has serious effects in increasing production costs and decreasing Crude oil price in world markets Additional costs are incurred upon the arrival of the product to the importing customers, and this entails significant material losses, in addition to its effects on oil equipment, as it is a catalyst for

dissolving acidic or corrosive base materials. Accordingly, the yield economic in the use of bioremediation technology constitutes a supportive part of the national economy by maintaining the quality of the product and reducing the losses caused by microorganisms in accordance scientific and economic controls as it is the main factor in development and production sustainability.

References

[1] Dorota Wolicka and Andrzej Borkowski, Microorganisms and Crude Oil, Introduction to Enhanced Oil Recovery (EOR) Processes and Bioremediation of Oil-Contaminated Sites, Edited by Laura Romero-Zerón ISBN: 978-953-51-0629-6. 2012. Poland.

[2] Michel Mogot, Bernard Ollivier & Bharat K. C Patel. Microbiology of petroleum reservoirs, Kluwer, Academic, 77: 103, 116, 2000, Netherland.

[3] Friedrich Widdel and Ralf Rabus. Anaerobic biodegradation of saturated and aromatic hydrocarbons, © Elsevier Science Ltd.. 12: 259–276, 2001, Germany.

[4] George V. Chilingarian,, Microbial enhanced oil recovery, © Amsterdam. New York, Elsevier, Amsterdam, vol 22 1996, U.S.A.

[5] IP Standard Test Methods for analysis and testing of petroleum and related products, and British Standard Parts. vol 3, 2022, U.K.

[6] J. B. Davis. Petroleum microbiology, Elsevier Publishing. 2007, New York. USA.

[7] Jonathan D. van Hamme,, Recent Advances in petroleum Microbiology, American society for microbiology, 2003 U.S.A.

[8] John A. Veil, Markus G. Puder Markus Elcock Robert J. Redweik, Jr, A White Paper Describing Produced. Water from Production of Crude Oil Natural Gas, and Coal Bed Methane. National Energy Technology Laboratory, 2004, USA.

[9] Heinz Wilkes, Andrea Vieth. Biodegraded oil reservoirs to show that this concept is applicable to a broad range of hydrocarbon and non-hydrocarbon constituents of petroleum, © AAPG Calgary, Alberta, June 16-19, 2005. Pakastan.

[10] Wei E. Huang. Rapid characterization of microbial biodegradation. Pathways by FT-IR spectroscopy, Journal of Microbiological Methods 67 (2): 273-80 (2006). U.K.

[11] Feitkenhauer H, Muller R, Marakl, Degradation of polycyclic aromatic hydrocarbons and long chain alkanes at 60-70 C by Thermus and Bacillus spp Biodegradation; 14; 367 -372 doi; 10.1023/A;1027357615649. 15 (1): 77, 2003, USA.

[12] Widdel, 2001, Anaerobic biodegradation of saturated and aromatic hydrocarbons, © Elsevier Science Ltd. All rights reserved. Volume 12, Issue 3, Pages 259-276. 1 June 2001, UK.

[13] M. A. Rasheed, D. J. Patil and A. M. Dayal. Microbial Techniques for Hydrocarbon Exploration, DOI: 10.5772/50885, Edited by Vladimir Kutcherov and Anton Kolesnikov 16th, 2011, UK.

[14] Noah yossef, Mostfa Elshahed and Michael 2009, Advances in applied microbiology © Elsevier Science academic press Burlington: Academic Press, Vol 66 pp. 141-251. ISBN: 978-0-12-374788-4 © Copyright 2009 Elsevier Inc. Academic Press. 2009, UK.

[15] Punniyakotti Elumalai, Punniyakotti Parthipan, Bacillus and Geobacillus on crude oil degradation and bio corrosion in oil reservoir environment Author information Article notes copyright and License information Disclaimer, Published online 2019 Feb 12. doi: 10.1007/s13205-019-1604-0, 2019, USA.