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Converting Carbon Dioxide in to Methane Gas and Enhance Oil Recovery by using Biotechnology Process

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Abstract

Using biotechnology in petroleum industry has many advantages .for example , Microbiologically Enhanced Oil Recovery (MEOR) increase of the productivity of the oil field and decrease the viscosity of the crude oil . It's known that atmosphere has considerable amount of CO₂ gas as a result of industrial activities (crude oil production). CO₂ gas plays a role in increasing atmosphere temperature and causing global warming. Bioremediation is a viable Biotechnology function for Re-producing depleted wells and global warming. It means Bioremediation uses metabolic adaptation of microorganism, a promising approach, using this technique employs of Methanogenic bacteria to convert CO₂ gas in to CH₄. Therefore turns carbon dioxide in to carbon which is added to crude oil (so contribute decrease the viscosity for heavy crude oil, This mechanism is a part of the promotion of oil production.it is apart an operation EOR. and Second reacts with Hydrogen by Bacteria to produce methane gas. The aim study, advantage this method increase production. and removal global warming. In this review, we discuss the role of Methanogenic bacteria in transforming CO₂ gas into methane gas , that it has a role in crude oil production . Methanogenic bacteria have an important role in petroleum industry and environment during decreasing CO₂ amount in the atmosphere and increasing reservoir pressure. MEOR technology uses strains that have a role in crude oil production; these bacterial strains produce biogases (Methane) that increase reservoir pressure. In this study, six strains were isolated from Rumaila oilfield, south of Iraq. These strains were identified based

on microscopic and morphological observations. These strains were Methanogenic bacteria. The main part of this study includes identification of bacteria that can consume CO₂ gas and making continual lab experiments to isolate and determine the best genus to do this process in oil field. Experiments were done in specific bio-labs for two years, Methanogenic bacteria strains were isolated by using specific selective growth media. The second part of this study is using these strains for bioremediation process of oil wells, which includes providing anaerobic conditions for these strains to transform CO₂ gas to methane. Morphological and microscopic observations were conducted to these strains and showed the best kind of these strains according to the ability of transformation of CO₂ to methane. The isolated bacteria were called BRS11 strain showed high efficiency in transformation of CO₂ to methane.

Keywords: Rumaila field, thermophiles bacteria, Methanogenic bacteria, MEOR, Gas chromatography.

1. Introduction

Integrating CO₂ gas catching and storage technology into oil reservoirs, with biotechnology to return depleted wells to production in an unconventional manner that begins with the injection of CO₂ gas into oil reservoirs to move the remaining oil in the pores by entering the gas into the rocks of oil tanks and leading to chemical and physical reactions that contribute to raising the reservoir pressure [9] and obtaining additional quantities of oil that cannot be released without resorting to this process as in the Figure No. (1), this method is a technique for enhanced oil production EOR, and the main part is the provision of a cost-effective CO₂ gas catching and storage technique that encourages its use to extract more crude oil.

1.1 EOR Enhanced Oil Recovery using Carbon Dioxide

One way in which oil production is increased is other than traditional methods, as the injection of CO₂ gas into oil reservoirs leads to the movement of the remaining oil in the pores by entering the reservoir rocks and the occurrence of chemical and physical reactions leading to the promote of reservoir pressure [9] which helps additional quantities of oil that cannot be released without resorting to this process as in the Figure

(1). However, the main constraint in providing adequate quantities of CO₂ gas at an acceptable and appropriate cost that encourages its use to extract more oil, the backbone of the economy and its main source, can be provided using carbon-catching techniques.

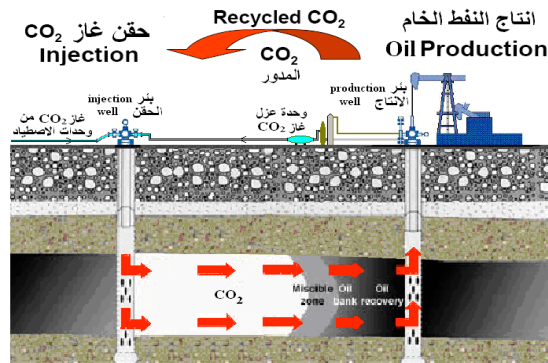


Fig. (1): Demonstrates oil production processes by injecting CO₂ gas

1.2 Motives to bring depleted oil and gas wells back to work by injecting gas CO₂

Oil and gas concentrations are usually found in high permeable and porous rock reservoirs such as limestone rocks and sand rocks, and after reservoir pressure drop, oil production is affected and cannot be extracted from those reservoirs and extraction is stopped, although the reservoir contains good amounts of reserve, the pressure inside the reservoir is raised by using water injection below the reservoir to increase the amount of oil remaining, but in heavy oil reservoirs where the rest of the oil is extracted, the tertiary recovery production is using Recovery thermal methods.

To reduce the viscosity to facilitate its flow or by injecting chemicals to dissolve reservoir rocks, especially carbon or solvents that increase the mixing of chemical compounds. In any case, this process needs more energy, and financially expensive. Other experiments inject carbon dioxide into the aquifers so that it mixes with oil and reduces the production and push of oil outside the well and the injection must be so high that it helps to mix CO₂ with the remaining oil and take advantage of the physical specifications of carbon dioxide gas as in Table (1).

Table (1) Physical properties of carbon dioxide

NO.	value & Unit	Character
1	44.01	Molecular weight
2	-78.5 °C	Boiling point**
3	571.3 kj / kg	Latent heat of vaporization**
4	135.0 Btu/ lb at 100 °C	Heat content
5	73 atm	Critical pressure
6	31 °C	temperature Critical
7	1797 cm ³ / L at 0 °C 900 cm ³ / L at 20 °C	Solubility in water*
8	1.9769 gm / L at 0 °C and 1 atm	Density*
9	1.53 (air = 1)	Specific gravity*
10	0.85 kj /kg	heat Specific*
11	762kg/m ³ at 21.1 °C and 1 atm	Density**
12	1.18 (water = 1)	Specific gravity**
13	830 psi at 20 °C	Vapor Pressure**
14	0.07cP at – 78 °C	Viscosity**
15	-56.6 °C at 5.2 atm	point Melting**
16	-78.5 °C at 1 atm	Subliming point***
17	25.13kj/mol	Latent Heat of Sublimation***

*Properties that apply to carbon dioxide CO₂ gas

**Properties that apply to liquid carbon dioxide liquid

***Properties that apply to solid carbon dioxide (dry ice) [14]

The process coincides with flooding water, where water is injected to restore pressure within the reservoir to the appropriate recovery value. The feasibility of using the enhanced oil extraction process technology using CO₂ is achieved mainly at the API density level, which determines the success of the use of this technique[5] and the Organization of Petroleum Exporting Countries (OPEC) has identified crude oil types as follows: light top API 35° and medium within the field (higher than API 26° and below API 35° and heavy oil below API (26°), and another important criteria is

reservoir pressure at the beginning of CO₂ injections requiring higher than the minimum. Minimum Miscibility Pressure

This is to ensure a good combination of CO₂ and the oil in the reservoir [23]. Therefore, the process of injecting CO₂ gas into oil reservoirs is to prolong the life of the oil fields, especially after the initial extraction and water flooding processes have been exhausted, so it is called the third extraction as in the Figure (3) and was utilization in the early 1960s by the United States.[21] Here is the goal of the research, which is part of tertiary production third extraction method by employing biotechnology bacteria from oil reservoirs to improve crude oil specifications, one of the advantages of which is to increase the intensity (API) and reduce its (Viscosity). Since 1926, bacteria have been used in the chemical engineering industry and the discovery of bacteria from oil wells since 1930 [4] by researchers in the former Soviet Union and countries, France, Japan, China and the United States of America are racing through their scientific centers studies in this field [1]. Therefore, the idea of research is to employ microorganism

.In several areas, to achieve (enhanced oil extraction) as an important economic means in the oil industry and not only to convert CO₂ into methane and contribute with global countries to reduce CO₂ emissions and on the principle of clean development mechanism (CDM). It is clear that the research is primarily aimed at restoring depleted oil wells. To take advantage of methane production to improve production because it is lighter than oil and creates a layer above oil called cap gas, which accompanies oil during production and is called associated gas. This increases the reservoir pressure of oil wells and increases production capacity, as in the Figure (2). To address the increasing proportion of CO₂ gas emitted into the atmosphere caused by the combustion of large quantities of fossil fuels, leaving large quantities of CO₂ gas. One of its effects is global warming and climate change, which is a global challenge because of its significant impacts on the environment and biodiversity of nature. In order to catch up with developed countries in the field of biotechnology in various industrial fields. this technology that combines several objectives that unite with biotechnology, which, if applied, has a bright future in our dear country and the world .

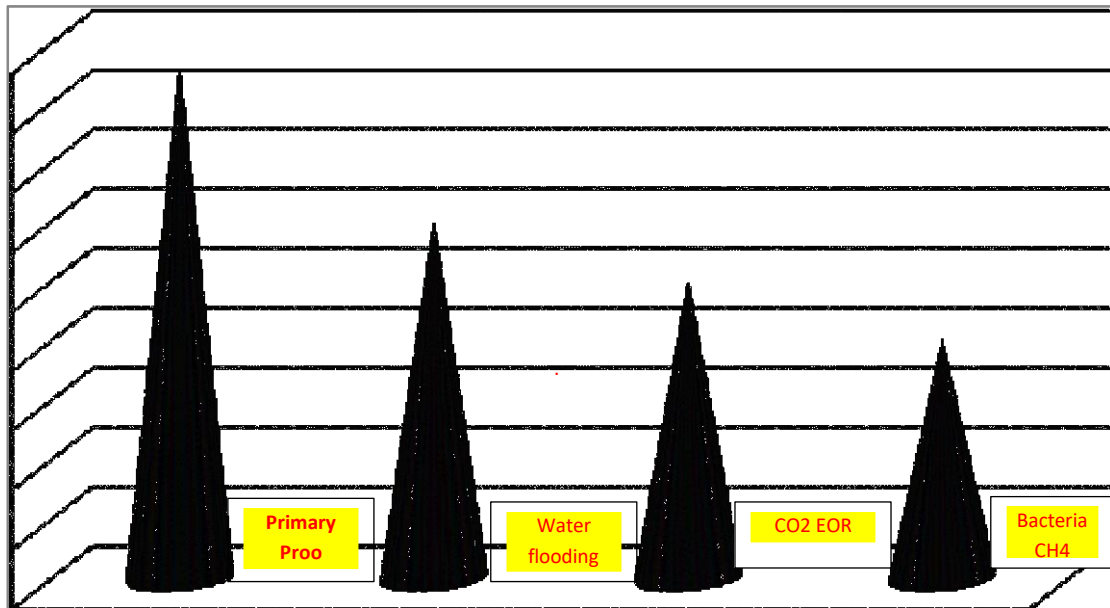


Fig. (2): The sequence of oil production methods used

1.3 Increased CO₂ gas.

Increased CO₂ gas from permitted limits results in problems leading to increased air temperature and climate change, and this environmental phenomenon is known as global warming. Scientists of environmental organizations agreed to identify rising temperatures as the most important causes of the climate changes sweeping the globe due to the emission of CO₂ gas, its increase in atmospheric proportions and the multiplicity of its sources, as in Table (2).

Table (2) Carbon gas sources in nature

NO	Source type	Percentage
1	Forest_loss	1%
2	Fossil fuels	4%
3	Respiration	38%
4	Ocean surface	57%

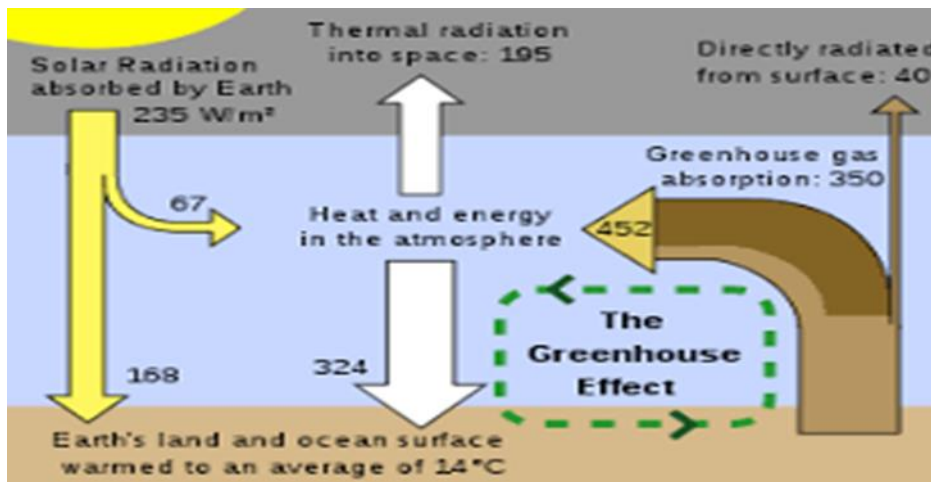


Fig. (3): Impact of global warming

1.4 Greenhouse gases

Greenhouse gases consist mainly of carbon dioxide and other gases that are considered to be small in relation to carbon gas, including methane and N₂O, as well as CFC chlorofluorocarbon gases, and according to greenhouse gas ratios shown In Table (3), it is clear that the biggest cause of global warming is carbon dioxide, which alone accounts for 99.4 percent of greenhouse gases, causing infrared sequestration within the Earth's atmosphere, causing a rise in The earth's temperature due to the increase resulting from the burning of fossil fuels (crude oil products, coal) causing the concentration of carbon dioxide in the atmosphere to gradually increase to about 378 ppm in 2006 as in Table (4).

Table: (3) Concentration of greenhouse gas emissions in the atmosphere [12]

NO.	Percentage	Type of gas
1	99.438	CO ₂
2	0.471	CH ₄
3	0.084	N ₂ O
4	0.007	CFC

Table (4) Carbon concentration in the atmosphere over the years [12]

NO.	Carbon gas concentration(ppm)	The year
1	280	1740
2	285	1820
3	290	1850
4	295	1890
5	300	915
6	305	1930
7	310	1950
8	317	1960
9	325	1970
10	339	1980
11	353	1990
12	359	1995
13	378	2006

1.5 Phenomena expected as a result of global warming

- Melting ice due to rising temperatures that will lead to the sinking of low-lying islands and coastal cities.
- Increased floods, agricultural disasters and loss of some crops.
- Extreme weather droughts and desertification of large areas of land increase forest fires [13].
- Increase the number and severity of storms and hurricanes (this is evident in the large number of dust storms affecting Iraq's climate).
- The spread of infectious diseases in the world and the extinction of many living organisms.

1.6 Special international treaties aimed at reducing greenhouse gas emissions, especially (CO₂)

Since the industrial revolution of 1750, CO₂ concentration has increased by 0.35% from 2006 to 378 parts per million [19]. Due to the use of fossil fuels, CO₂'s concentration has increased to a level considered dangerous. Greenhouse gas production as pledged by the Kyoto Protocol in 1997 [15] and reduced greenhouse gas emissions by 5% from 1990 rates, and recommended projects in developing countries based on the principle of technology Development Mechanism Clean.- CDM [11]. This

axis includes eliminating the significant increase of CO₂ gas from the atmosphere and converting it into methane and reducing global warming, through the application of biotechnology, a modern method (biotechnology Environmental), which requires the use of carbon catching technology and storing it in the geological reservoirs of depleted oil wells

1.7 Capture CO₂

It is a technique for collecting carbon gas from its sources and holding it apart from other associated gases and transporting it to the storage site to isolate it from the atmosphere in order to reduce greenhouse gas emissions and control their concentration in the atmosphere [12]. CO₂ gas is injected into depleted oil and gas tanks or deep saline formations as in the form of Figure (4), a technique applied in the oil industry [25], and these systems remain limited in reducing carbon dioxide emissions because they require the creation of storage sites with the ability to retain large quantities of gas produced annually and this is extreme The difficulty in maintaining these quantities without full treatment. For the purpose of making use of them, they need to be deployed at energy production sites and the industrial sector, which account for 85% of emissions. [2]

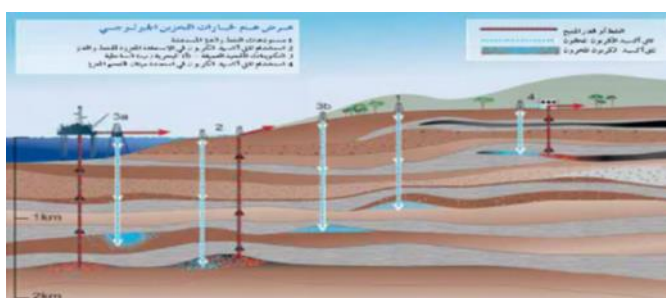


Fig. (4): CO₂ gas storage mechanism

2. Working methods and materials

2.1 Laboratory devices and materials used:

1. Incubator.
2. Cool Incubator
3. Shaker Incubator
4. Anaerobic – Jar.

5. Autoclave.
6. Microscope.
7. Dyes, crystal violet, Safranin.
8. 8. Gas Chromatograph, Agilent Technologies 6890.
9. Media for Characterization of Bacteria.

This includes a wide range of transplant communities and is used to determine the type of bacteria from the total microbiology.

A- The first medium: Prepare of components and the amount additives

MgSO₄.7H₂O=1g, CaCl₂.2H₂O=0.5g, Cysteine hydrochloride=1g, K₂HPO₄=1g, KH₂PO₄=1g, (NH₄)₂SO₄=2g, NaCl=5g, PH= 7, Agar=5g, NaS.9H₂O=1g, Sodium format=0.01g.

B- The second medium: a material has been added to activate the center and change the amount of its components as follows:

MgSO₄.7H₂O = 0.09g, CaCl₂.2H₂O = 0.06g, Cystien hydrochloride =0.3g, K₂HPO₄=0.22 g, KH₂PO₄=0.22 g, (NH₄)₂SO₄=0.22g, NaCl =0.44g, Agar =5g, NaS.9H₂O=0.3g, Sodium format=0.01g, Rizosorin sodium =0.01.

C- Natural Media: a food medium that develops a wide range of bacteria and microbiology was used in nutrient agar.

2.2 The stages of completion of the research are as follows

2.2.1 Sample collection

A. Sampling of oil sites: 26 samples of crude oil, (9) samples of reservoir water and (9) raw water samples were collected and modelled by 10 ml sterile glass bottles to take a quantity of Crude oil or reservoir water, to investigate the methane-producing bacteria of oil fields (Northern and Southern Rumaila, West Qurna, Zubair and Ben Omar River) Basra Oil Company as well as fields (Fakeh, Bazarkan and Abu Ghab) Maysan Oil Company.

B. Take samples from other environmental sites. Collected (6) water samples from the areas of the Shatt al-Arab River near the Ben Omar River site, the monastery area and the paper plant.

2.2.2 Isolation and Pure Culture Techniques

Bacteria develop on a food medium prepared (Culture) in the laboratory and show different types of bacteria on the same medium and different species are distinguished by the external appearance and characteristics of the medium to reach the diagnosis of the type of bacteria shown according to the following steps:

A- Presumptive test: Examine samples (crude oil, reservoir water, contaminated water) by taking one ml per sample and grow in a general medium for the development of all species that follow this sex and leave for three weeks at a temperature of 40°C.

B- Most Probable Number (MPN): Diagnosis of bacteria in an eclectic medium and study of their appearance qualities.

C- Confirmed test Activation of bacterial insulation (pure bacteria): Part of the isolated colony is taken to produce a new generation taken by a sterile lobe to the center and placed in the device for a period and at an appropriate temperature we will get pure bacteria and to make sure the purity is microscopic and compared to the previous images of it.

2.2.3 The Microscopic Examination of Bacteria

The appearance characteristics of bacteria are observed by placing them on a special slide with a drop of water (Wet Mount) or a fixed state in which the external appearance and structural organization of cells are usually illustrated by a microscope and photographed and compared with other forms of developing bacteria to monitor the various qualities captured by the microscope as shown in the Figure (5).

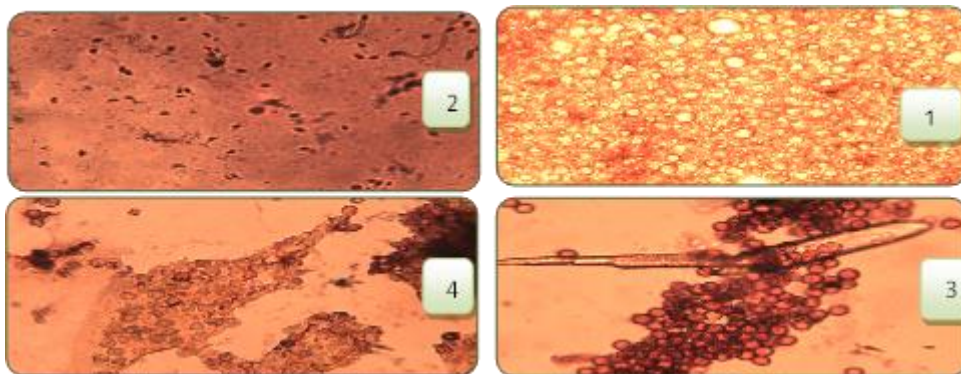


Fig. (5): The various qualities of developing bacteria captured by the microscope

Use of dying, Place a drop of Crystal violet dye on the slice containing bacteria for (half a minute) wash the slide with distilled water and then soak the slice with iodine solution for a period (half a minute) and then wash the slide with distilled water and then soak the slice with alcohol Ethanol for (1-2 minutes) and then wash with distilled water and add a drop of Safranin dye for 1-2 minutes and then wash with running water and then perform a painful examination.

2.2.4 Testing the efficiency of methane-producing bacteria:

According to the machine steps:

A- Activate the bacteria on a selective medium prepared for methane bacteria with an envelope for the production of CO₂ gas in a closed container (Anaerobic-Jar) to prepare them for examination by conducting from the GC chromatograph to a container valve.

B- Prepare a container with a food center prepared for methane bacteria and provide standard pure CO₂ gas through injections.

C- Preparing a container in a food center without bacteria as a control sample and with an envelope for the production of CO₂ gas.

D- Preparation of a nutrient agar container for methane-producing bacteria with an envelope for CO₂ gas production for comparison.

2.2.5 Chromatograph gas technology:

Use Agilent Technologies 6890, a thermally insulated separation column (iso thermal hydrocarbon DC200) and helium gas pass as a 30-pound/ing²-pressure carrier gas at a rate of 10 ml/minute on a FID detector. Containers intended for examination are transported for the purposes of verifying their efficiency in converting carbon dioxide into methane and diagnosing the most efficient of the types tested shown in picture 7 and experiments using the GC gas technology as shown in Figure (6).

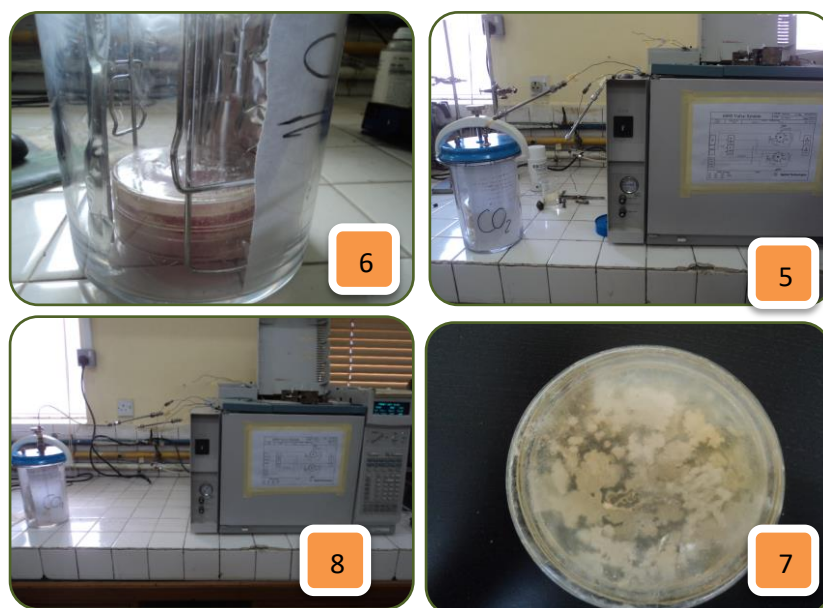


Fig. (6) The experiments using the gas Chromatography (GC) technology

3. Results and Discussion

After collecting samples from the oil fields through the biological survey of both (The Northern and Southern Rumaila Field, Zubair Field, Bazarkan Field, Al-Fakah Field, Abu Gharbi Field, West Qurna Field) and environmental sites (Deir, Ben Omar River). Isolated by methane-producing bacterium (MPB) bacteria, as in Table (5), the growth and density of bacteria for oil field samples was higher than for other sites. Laboratory-prepared selective communities were used to detect bacteria and in two phases the first was the use of a medium that develops all types of methane bacteria and the second selectively to diagnose bacteria Media for Bacteria Film [6] To contain these circles on elements that stimulate the growth of Methanogenic bacteria that contribute to the selection of bacteria from samples and the election of the best of them. Oil sites were higher than the rest because the dietary pattern of methane-producing bacteria is Chemolithotrophic. This pattern enables bacteria to adapt to the oil environment because of enzymes that help consume raw materials such as CO_2 and its methane outputs by metabolic process that consumes electron from its hydrogen molecule and reduces CO_2 to CH_4 in anaerobic conditions[17] and consumes H_2 gas as an electron and a donor of crude oil and the future CO_2 gas to produce methane [14], which gives importance in the use of bacteria in oil reservoirs for their ability to exploit various

compounds and benefit from them in metabolism. The growth rate in the reservoirs affects the degree of adaptation of bacteria and the second water flooding, which provides multiple nutritional components that lead to the diversity of bacteria populations, increase their number by location and increase their activities, and vary according to the enzyme qualities of methane-producing bacteria. The other dietary pattern of bacteria is autotrophic, carbon is consumed by hydrocarbons and hydrogen gas is inflated to interact with other gases as a future of electrons such as CO₂ and integrates with hydrocarbon compounds, helping to change and improve crude oil specifications. Dietary pattern therefore has a role to play in choosing the type of bacteria to achieve the goal of converting CO₂ into methane. To demonstrate the effectiveness of bacteria, examine the efficiency of transformation and identify active species, use the GC [7], which determines the best conversion results from CO₂ to methane to choose the effective type of bacteria and according to the standard reading of the GC device. As in Figure (7).

Table (5) Investigation of methane-producing bacteria at oil sites

NO.	Site	sample type	Type of media	Results		Date
				Anaerobic	aerobic	
1	North Rumaila Field / DS3	crude oil	Nutrient	+	-	2012/2/11
2		Water Reservoir D1	Nutrient	+	-	2012/2/11
3		Water Reservoir D2	Nutrient	+	-	2012/2/11
4		Water Reservoir D1	Nutrient	+	-	2012/2/11
5		Water Reservoir D2	Nutrient	+	-	2012/2/11
6		Water Reservoir D2	Nutrient	+	-	2012/2/11
7	Al, Fakah field	crude oil	Methanogenic (1)	+	-	2012/2/1
8	Bazarkan Field	crude oil	Methanogenic (1)	+	-	2012/2/1
9	Abu Gharb field	crude oil	Methanogenic(1)	+	-	2012/2/1
10	Al, Fakah field (1)	crude oil	Methanogenic (2)	+	-	2012/2/20
11	Bazarkan Field (1)	crude oil	Methanogenic (2)	+	-	2012/2/20
12	Abu Gharb field (1)	crude oil	Methanogenic (2)	+	-	2012/2/20
13	Al, Fakah field (2)	Raw water	Methanogenic (2)	+	-	2012/2/20
14	Bazarkan Field (2)	crude oil	Methanogenic (2)	+	-	2012/2/20
15	Abu Gharb field (2)	crude oil	Methanogenic (2)	+	-	2012/2/20
16	Ben Omar Field (1)	crude oil	Methanogenic (2)	+	-	2012/2/20

17	Ben Omar Field (1)	Raw water	Methanogenic (2)	+	-	2012/2/20
18	Al, Fakah field	crude oil	Methanogenic (2)	+	-	2012/3/27
19	Bazarkan Field	crude oil	Methanogenic (2)	+	-	2012/3/27
20	Abu Gharb field	crude oil	Methanogenic (2)	+	-	2012/3/27
21	Paper Factory	Raw water	Methanogenic (2)	+	-	2012/3/27
22	Artawi Field	crude oil	Methanogenic (2)	+	-	2012/4/4
23	Artawi Field	Water Reservoir D1	Methanogenic (2)	+	-	2012/4/4
24	Ben Omar Field	Contaminated water	Methanogenic (2)	+	-	2012/5/28
25	Ben Omar Field	Shatt al, Arab raw water	Methanogenic (2)	+	-	2012/5/28
26	Bazarkan Field	crude oil	Methanogenic (2)	+	-	2012/5/28
27	Deir Area	Contaminated water	Methanogenic (2)	+	-	2012/7/22
28	North Rumaila Field / DS3	crude oil	Methanogenic (2)	+	-	2012/9/8
29	North Rumaila Field / DS3	crude oil+ Water from a hole	Methanogenic (2)	+	-	2012/9/8
30	Ben Omar Field	crude oil	Methanogenic (2)	+	-	2012/8/16
31	A pure form of methane-producing bacteria	crude oil	Methanogenic (2)	+	-	2012/9/10
32	North Rumaila Field / DS3	Water reservoir	Methanogenic (2)	+	-	2012/10/21
33	North Rumaila Field / DS3	Water reservoir	Methanogenic (2)	+	-	2012/10/21
34	Laboratory (old model)	Eclectic medium	Methanogenic (2)	+	-	2012/9/23
35	Laboratory (old model)	Eclectic medium	Methanogenic (2)	+	-	2012/9/23
36	Laboratory (old model)	No bacteria.	Methanogenic (2)	+	-	2012/9/23
37	Laboratory (old model)	Eclectic medium	Methanogenic (2)	+	-	2012/11/19
38	South/ Rumaila Field central	crude oil	Methanogenic (2)	+	-	2013 /3/10
39	South/ Rumaila Field central	crude oil/1	Methanogenic (2)	+	-	2013 /3/10
40	South Rumaila Field / Shamia	crude oil/2	Methanogenic (2)	+	-	2013 /3/10
41	South Rumaila Field / Al-Qurainat	crude oil	Methanogenic (2)	+	-	2013 /3/10
42	North Rumaila Field / DS5	crude oil	Methanogenic (2)	+	-	2013 /3/10
43	West Qurna Field / DS6	crude oil	Methanogenic (2)	+	-	2013 /3/10

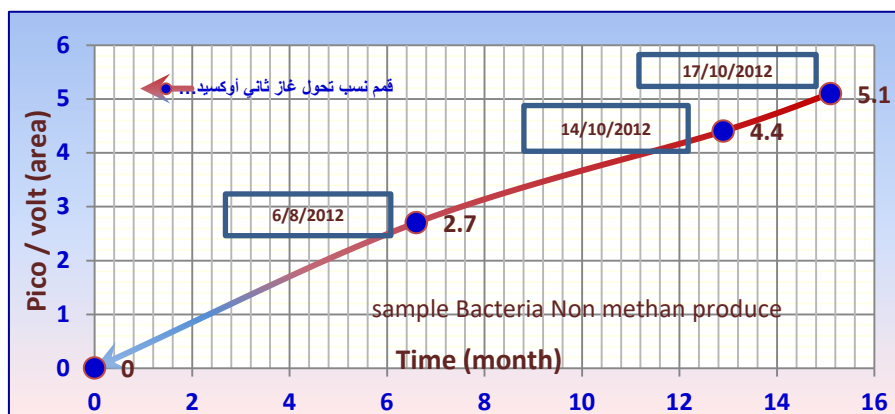


Fig. (7): The effective type of bacteria to convert CO₂ to methane according to the standard reading of the GC device

This variation in CO₂ consumption ratios to methane is due to the quality of enzymes for bacteria species where enzymes play a vital role in anaerobic environments, product fermentation, hydrogen consumption, and when there are compounds containing nitrates, sulfates and hexavalent iron, bacteria grow and activity by increasing CO₂ consumption and methane conversion, shown in the area of peaks of recorded charts of consumption, conversion and physical factors affecting the metabolism of micro-organisms (while obtaining ATP energy) is the temperature and salinity, which gives a variety of bacterial totals in oil reservoirs as in Table (6).

Table (6) Physical properties of southern field reservoirs

Reservoir properties	Field			
	West Qurna	Al Zubair	South Rumaila	North Rumaila
Reservoir	musharraf	Third aleata	Zubair AB	Musharraf
No. Well	WQ-60	Zb-58	RU-105	R-19
Depth (m)	2514.29	3366	2430	2246
Oil gravity (gm/cm ³)	0.9319	0.7104	0.7782	0.897
Permeability (MD)	3.6	43	34	46
Salinity (ppm)	254000	223000	239000	72000
Reservoir Temp. (°C)	78.7	100	98.9	79.8

The extent to which methane bacteria adapt to surrounding factors varies according to the effect of salinity on the effectiveness of enzymes[8] as increased salinity reduces the

effectiveness of the enzyme and the effect depends on the type and nature of the enzyme and the amount of salts, so we can conclude that the bacterial efficiency index depends on the effectiveness of enzymes and for this reason the area of peaks increases or decreases for GC readings, causing different readings of the area of the peaks for methane conversion ratios as in Figure No. (8)

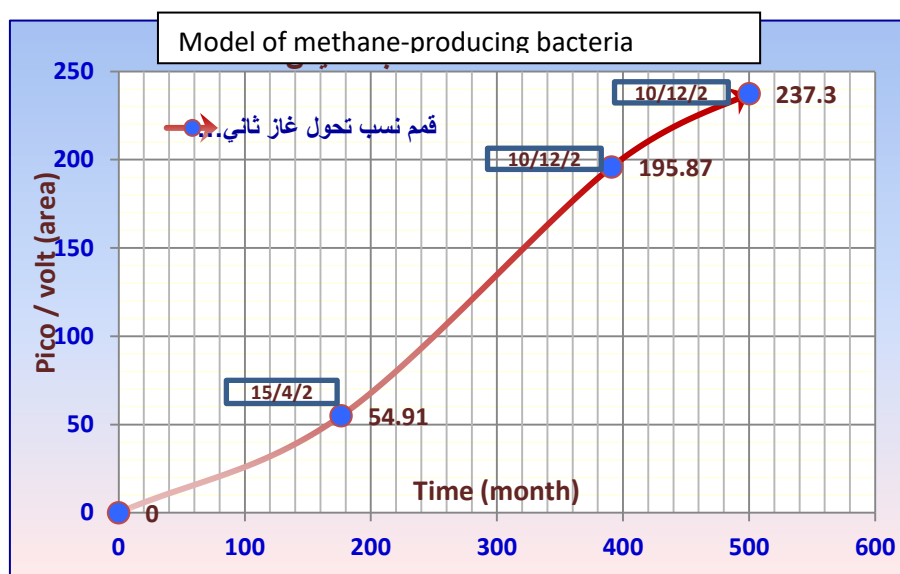


Fig. (8): Methane conversion ratios

Bacteria are becoming more diverse in oil reservoirs and their environmental origin is determined by the frequency of growth in environments, including oil reservoirs. After a series of time Retention experiments (2.03) minutes equal to peaks area (298.7) it was inferred that the amount of conversion to methane bacteria as in reading a distinct GC chromatograph for Figure (9) and reaching a pure strain with high efficiency in the disposal of CO₂ gas and its use in the oil industry, and the use of bacteria on the consumption and conversion of CO₂ gas

And based on this result it adds to crude oil an increase in the volume of gases and an improvement in its quality as shown by the reading of the GC chromatograph for Figure (10) and obtaining an effective strain which is the goal of reresearch to employ it on CO₂ gas consumption in the reservoir requires a great effort and diversity in the application of methods and communities used until the effective strain is determined so that To achieve this is a major achievement in itself and after these experiments we

have come up with a strain called BRS11 that has the potential to grow and produce methane.

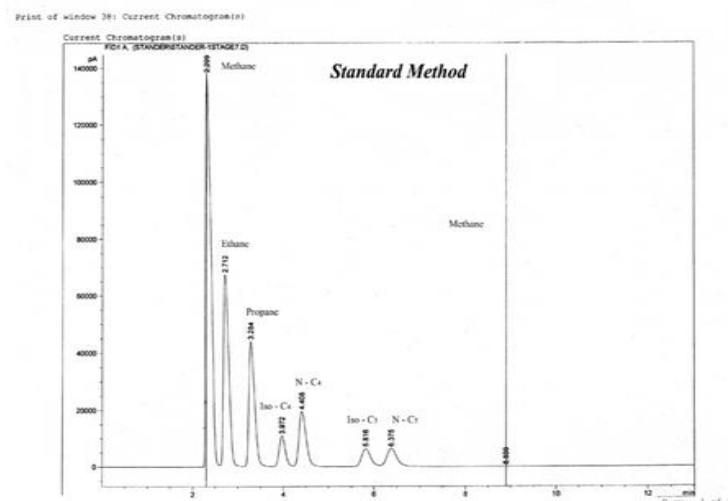


Fig. (9): The amount of conversion to methane bacteria as in reading a distinct GC chromatograph

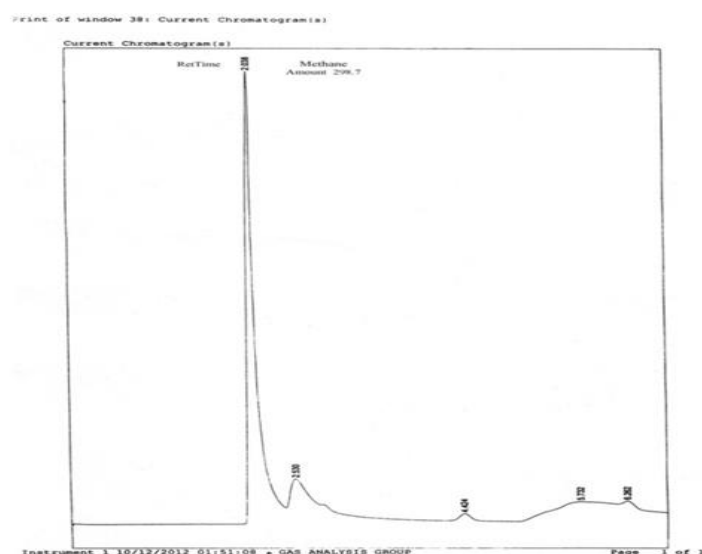


Fig. (10): The reading of the GC shows the increase in the volume of gases in crude oil

BrS11 strain was selected based on some physical factors as follows:

A. For being natural Indigenous where isolated from reservoir models (crude oil, reservoir water).

- B.** The degree of growth on models (oil, reservoir water) has given higher growth levels compared to other environments. Its ability to withstand high temperatures in oil reservoirs. Thermophilic bacteria.
- C.** Halophilic bacteria that may reach high concentrations fit with high salt-concentrated reservoir water and the fact that enzymes within bacteria are very high, helping to cope with high saline conditions. Our choice of this type of bacteria is important to withstand high temperatures when compared to similar bacteria where species and strains adapt to Methanogenic bacteria in different environments. The scientists also pointed out that it is important to determine the possibility of growth in the rate of high and low temperatures.[26]

Salinity factor has a role in the diversity of microbiology based on endurance and the ability to grow in saline conditions to three types of first called love to high salinity bacteria Halophilic and the second type bearing halotolerant bacteria and adapt to the environment. The third type that cannot grow in saline conditions is phobic bacteria Halo. [19]

In the light of these factors, it is clear to us that bacterial strains vary in metabolic activity and production giving based on these factors described in Table (5) of water models taken from the oil reservoirs in question and the degree of salinity was between (1172-67) This gives the impression that this BRS11 bacterial strain isolated from it as its natural habitat is appropriate under the geochemical conditions of these oil reservoirs [6] On this basis, the BRS11 strain was selected for use as a new vital means of controlling gas emissions. CO₂ and contribute to global warming. And its use in the enhanced oil production system (MEOR) and the final result is improved production of depleted wells and the extraction of remaining oil. The injection of CO₂ gas into oil reservoirs in secondary production processes triggers the movement of the remaining oil in the pores through its influence in the pores of the reservoir rocks and the occurrence of chemical and physical reactions that lead to the lifting of reservoir pressure and the acquisition of additional quantities of oil that cannot be released without resorting to this process more than is possible using conventional methods. There is nothing to hinder the technical application of this technique in various oil fields, but the main constraint lies in the availability of sufficient quantities of this gas

at an acceptable economic cost and the use of this method becomes affordable and encourages its use to extract more oil, which is the backbone of the economy and the main source of power generation in the world, so the need to use modern techniques is the methods of catching carbon dioxide. Capture and Storage CO₂ (CCS) It is a technological process in which carbon dioxide is collected from its industrial production sources and detained by separating it from other associated gases and transporting it to storage sites in order to reduce greenhouse gas emissions and control their concentration, and CO₂ gas catching technology depends on the use of physical or chemical solvents, membranes, solid absorption materials or refrigeration. If the source of this gas is a production plant, this is done after the fuel combustion process. It will be complementary to the biotechnology that leads to the conversion of CO₂ to methane and this has positive results in improving the production process where methane slowly leaks into small pits in nearby porous rocks that act as reservoirs for conservation, and since these rocks are usually filled with water, crude oil and gas being lighter than water and less dense than the surrounding rocks move up. In the end, some of these hydrocarbons, which are transported to the top of the layer, are locked up, not porous (water-impermeable) from the rocks known as Cap Rock. Because gas is lighter than crude oil, it creates a layer above crude oil called gas cap, and as a result of melting gas in oil, it improves crude oil specifications, increases production and generates new additional pressure as the main component of the associated gas. The second trend is the use of gas through gas processing units, which are less expensive because they are free of other gas pollutants that require high-cost treatment methods in addition to benefiting from it in various industrial fields such as electricity production, fertilizers and various chemical industries, making the application of these techniques collectively of great economic benefit in the oil industry.

4. Technical and Economic Feasibility

The application of biotechnology contributes to the support and support of the national economy as the main factor in development and the maintenance and increase of the sustainability of production Economic returns can be limited when using biotechnology as follows:

1. Return of depleted and production-dependent oil wells. The recovery of additional quantities of oil cannot be released by the usual methods of depleted wells and added to production from those stocks and increased strategic crude oil inventories.
2. Achieving additional economic return by increasing crude oil production and export to the world market.
3. Methane production contributes to the strengthening of the gas industry and its use in industrial fields, including electricity production.
4. The addition of scientific human resources that interfere with the sciences of oil geology, reservoir engineering and chemical engineering for the sciences of the biology of the oil industry contributes to solving problems in the oil industry that require these disciplines to overlap
5. The research offers advanced technology that not only leaves CO₂ gas as a stock but also benefits from it by restoring depleted oil wells and turning it into another gas of economic value and benefiting from it in the industrial fields and through investment and cooperation with oil companies licenses within a program to adopt the method of utilizing its expertise in its wide application in the oil industry.
6. The application of these technologies in oil reservoirs contributes to improving the petrochemical specifications of the reservoir and increasing the reservoir pressure
7. Storage costs range from (\$0.5-\$8) per ton of injected CO₂ gas and the cost is significantly reduced if storage is accompanied by enhanced bio-oil production and conversion to MEOR methane .
8. The positive return on tertiary oil recovery is the acquisition of additional quantities of oil estimated at 5-18% of the original Oil In Place geological reserve from the original oil in the reservoir, depending on a range of factors, the most important of which is the geological properties of the reservoir, the value of class pressure, the viscosity of the oil produced and the improvement of oil flow conditions, as in CO₂-EOR technology.

5. Conclusions

The research found the following:

1. Obtaining a bacterial strain with the potential and ability to grow by the physical conditions of oil reservoirs (temperature, pressure, salinity) and its ability to convert CO₂ into methane.
2. The sex of these bacteria (BRS11 strain) will later be studied as a new species previously undiscovered.
3. This type of bacteria has proven to grow in saline content of between (1,172-67,000) mg per liter, unlike what was proven in scientific sources that the growth range in saline content is between (35,000-45,000) mg per liter.
4. Enzymes are an indicator of the effectiveness of bacteria and that is why the area of peaks increases or decreases for GC readings.
5. Alternative energy production, since the main output is methane, which is one of the most important alternative energy sources for crude oil and is characterized by high-efficiency low-cost hydrocarbons that are low-emission polluting to the environment. It is also an important primary energy resource for the chemical industry and electricity production, methane is one of the most important alternative energy types and is an excellent type of environmentally friendly energy where this gas can be used for many purposes instead of oil, natural gas, coal and other traditional energy types.
6. Using CO₂ gas capture and catching technology eliminates method displacement Miscible CO₂ and pumps methane-producing bacteria that convert CO₂ into methane and recover residual crude oil as a result of increased reservoir pressure of the gas dome and the wells are ready to be re-produced with method is Miscible CO₂ displacement technology. We call this process the promotion of MEOR Bio-Oil Production.

Several objectives are achieved in that one of them when applying this technique is to eliminate CO₂ gas emissions in the atmosphere and to return depleted wells to production as a result of this process of enhancing oil production. Recovery Enhanced oil Microorganism (MEOR) [10]. From the foregoing, it is clear that the development of this technique is an advanced and advanced step in the field of scientific progress.

What they can achieve and the possibility of using these techniques in the oil industry can be summarized as follows:

1. Control of CO₂ gas emission sources in oil production plants.
2. Producing methane by using biotechnology by converting CO₂ into methane.
3. Storage and storage techniques CCS will be less costly when planning EOR-enhanced oil extraction projects in general, integrated with MEOR methane production projects.

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