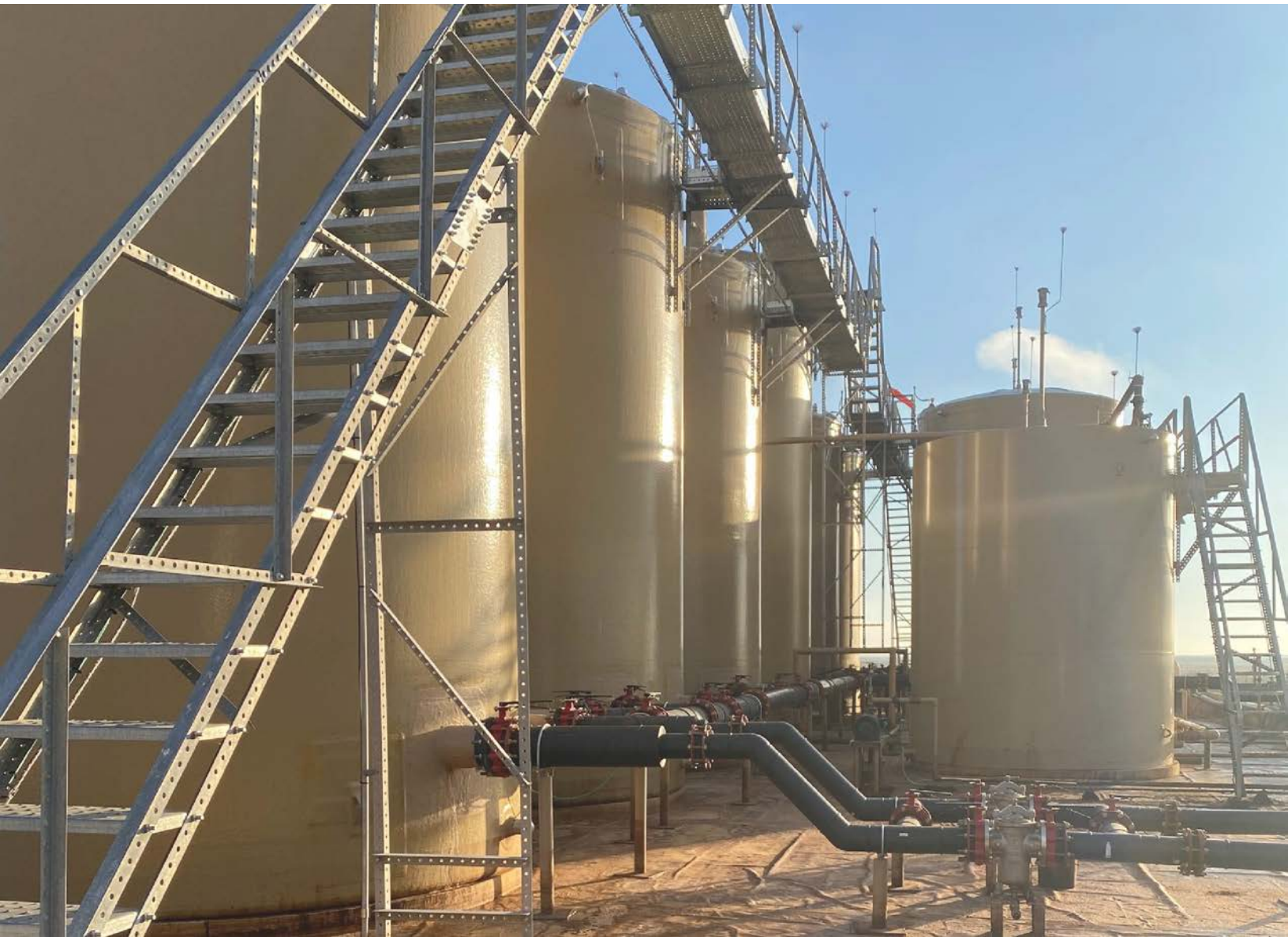
JGL SOLUTIONS
microbes at work

Remediating/Preventing Scale, Corrosion, and Hydrocarbon Carryover in SWDs and EOR Injectors **with Specialized Bacteria** vs. Traditional Chemicals



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Introduction

In harsh oilfield environments, scale and corrosion can cripple injection wells, for either SWDs or waterfloods. It can clog flowlines, tanks, filters, and downhole injection sites. The resultant reduction of inside diameters results in reduced flow rates and/or higher injection pressures. Restricted flow means less efficiency in SWDs—backlogging the injection of produced water—and reduced production from waterfloods. Higher pressures can cause costly damage to pumps and other equipment.

With SWDs, an additional issue can be the wasting of unseparated oil by disposing rather than collecting and selling it.

As investors increasingly press on E&Ps to produce cash flow with their oil and gas, many producers investigate ways to reduce expenses and boost production. One of the areas being examined is the costly use of chemicals in reducing the aforementioned scale and corrosion issues.

Top culprits in scale are iron sulfide and other iron compounds, calcium carbonate, and sulfates including barium, strontium, among others. Corrosion is mainly caused by oxygen in the water. Scale buildup can cover corrosion, making both issues harder to treat.

Challenges with Treating Scale and Corrosion **with Traditional Chemicals**

Traditional chemicals do offer some benefits, otherwise, they would not be used at all. But there are a number of shortcomings, including the following:

Cost and frequency

Several factors contribute to the high cost of chemical treatments.

A separate chemical or blend must be applied to each type of scale. Each chemical adds to the expense.

Due to continuous inflow of water loaded with scale-forming TSS and TDS contaminants, chemicals must be repeatedly or continuously injected. This further raises the costs.

In extra harsh environments or high water volumes, producers may never find it cost-effective to inject sufficient treatments to truly remedy scale or corrosion.

So they spend every affordable dollar and still operate at less than 100 percent efficiency—which adds further cost by increasing repairs or slashing productivity.

Toxicity

Toxicity issues require onsite personnel to take significant safety precautions with most chemicals. Touching, inhaling vapors, or **spilling most treatment chemicals can cause personal injury** or create an environmental hazard.

Microbial Alternatives

The idea of using microbes to recover oil goes back as far as the 1920s, but it was 20 years later before research began. In the last 20 years, the process has gained more acceptance as producers have, as previously stated, looked for procedures that reduced costs while still enhancing production.

A treatment program using blends of facultative anaerobic microorganisms (defined by their ability to thrive with or without available oxygen) continuously injected into the formation offers many advantages. These bacteria, also defined as specialized non-toxic, non-pathogenic, non-carcinogenic microbes are safe to handle, transport, and inject into the formation. This gives them the added benefit of being ESG friendly. Details of the benefits below are addressed in the case studies.

Effectiveness

Microbes have been shown to reduce or eliminate hot oiling and workovers significantly more than chemicals do.

Microbes differ from chemical treatments that must individually target each type of scale, and which tend to lose effectiveness as they travel through the system. With complete testing and assessment of the scales, water, geology, and equipment, a single microbe mixture can deal with every detected issue.

Microbial Alternatives

Scale

Properly designed microbe blends dissolve scale based on iron sulfide and other iron compounds, along with calcium sulfate, calcium carbonate, barium sulfate, strontium sulfate, and many others.

Some scales, like barium, are too dense to break down in a reasonable time frame. For these, the treatment requires microbes that chelate barium, iron compounds, and calcium carbonates, binding them to prevent scale formation.

Sulfate-reducing bacteria (SRBs) may also contribute to scale. Microbes designed to break down scale have an added benefit in that they compete for some of the same trace elements vital to SRBs, in effect, starving them out. By eliminating these SRBs the microbes also eliminate H2S, further reducing the opportunity for iron sulfides to grow. Other microbes reduce hydrocarbon carryover including paraffin and asphaltenes.

Corrosion

Most corrosion is facilitated by the presence of oxygen in the system. Facultative anaerobes are ideal for treating this issue because they adapt to both aerobic and anaerobic pathways. They use aerobic pathways until oxygen is diminished, then transition to anaerobic, allowing them to flourish downhole. Removing oxygen also robs corrosion of its main catalyst, demonstrated in the case study to follow.

Oil Separation

Many producers lose significant revenue by failing to remove residual oil, instead, allowing it to be injected into SWDs. In some cases, SWD operators separate and sell the oil themselves. One group of microbes creates surfactants highly effective at separating oil from produced water, so this oil can be sold. In this way, the microbe treatments more than pay for themselves from the increased revenue. It also reduces the amount of hydrocarbons injected into SWD formations.

Microbial Enhanced Oil Recovery (MEOR) and Increased Output

Certainly, the first goal of microbe treatment in a waterflood is to increase flow and/or reduce pressure and strain on pumps. When the mix includes surfactant-producing microbes, there is an added benefit. Once injected, the microbes travel on their own, reaching residual oil trapped in tiny rock capillaries that chemicals cannot reach. At two-tenths of a micron in size, they easily move into tight pore spaces. Biosurfactants they produce behave as nonionic and weak anionic surfactants. **The resulting surfactants lower interfacial tension by up to 90%. This reduces capillary forces, which is what releases residual oil.**

In contrast, chemical surfactants tend to be absorbed by other surfaces along the path, depleting their effectiveness before they can blanket the formation. Because microbes produce surfactants in situ, they eliminate this issue.

Surfactant-producing microbes also mobilize the oil by significantly reducing its viscosity. Often, the end result is an incremental boost in oil production. This miscibility speeds communication of water through waterfloods. Instead of the typical 7-9 months to disperse, some operators see production increases in a single month.

Tax

Both the Federal government and many states offer tax benefits to producers in fields where they employ MEOR methods. For example, **the State of Texas gives 50% severance tax credits on all oil produced in microbe-treated areas**. They typically want to see sustained positive results for 5-6 months before authorizing the credit.

Other states may require a longer period, and some discounts depend upon the price of oil and other economic factors.

Determining the Blend Through Testing and Evaluation

Evaluation of a location begins with a site visit and extensive interviewing of personnel to determine the amount of corrosion/scale produced and the frequency and type of treatments that have been tried. The next step is lab testing of fluid and solid samples. These tests provide information on how amicable the formation fluids are to the microbes and information on scale sources such as calcium carbonate, iron sulfate, etc., along with any hydrocarbon carryover, corrosion, or other factors.

From this information, a particular blend of various microbe colonies can be combined to specifically target the issues detected in the system.

Billions of microbes are injected at the chosen intake vessel such as the intake tank, gun barrel tank, water knockout, or elsewhere. **Injections are scheduled at a frequency designed to maintain approximately one million cells per milliliter of fluid at all times.** Amounts and intervals are determined by fluid samples designed to reveal the hostility of the environment, retention time, and tank battery makeup.

After implementing the treatment, ongoing filtered solids analysis is necessary to document water quality improvement and to alert of any necessary adjustments to the treatment design as things change in the system.

- **Patience**

  It is important to note that waterfloods encompass large areas, which can require weeks or even several months for any new treatment to reach all corners of the field. After that, more time is required for hydrocarbons to break free and reach the producing wells. Production changes may be visible in some producing wells before others, depending on their proximity to injection wells. Scales also may require some lead time, depending on their severity and composition.

In the Field - Case History

A Kansas operator turned to microbes for waterflood solutions in 2017. They chose water tanks for the injection point in order to see the benefits throughout the entire system.

Goals

The operator needed to reduce pressures and increase volumes to injection wells for SWDs and waterfloods. Their ultimate goal for waterfloods was to more effectively sweep the producing formations.

The Results

A number of injection wells have increased volumes with unchanged pressures. Others have dropped injection pressures while increasing volumes.

One well began the program injecting 21 BWPD at 551 PSIG, moving to injecting 221 BWPD at 300 PSIG.

As planned, microbes benefitted the entire system. In tanks, microbes released suspended hydrocarbons including residual oil, paraffin, and emulsion, floating them to the surface to be skimmed off instead of injected.

This has reduced tank bottom cleaning costs by 50%.

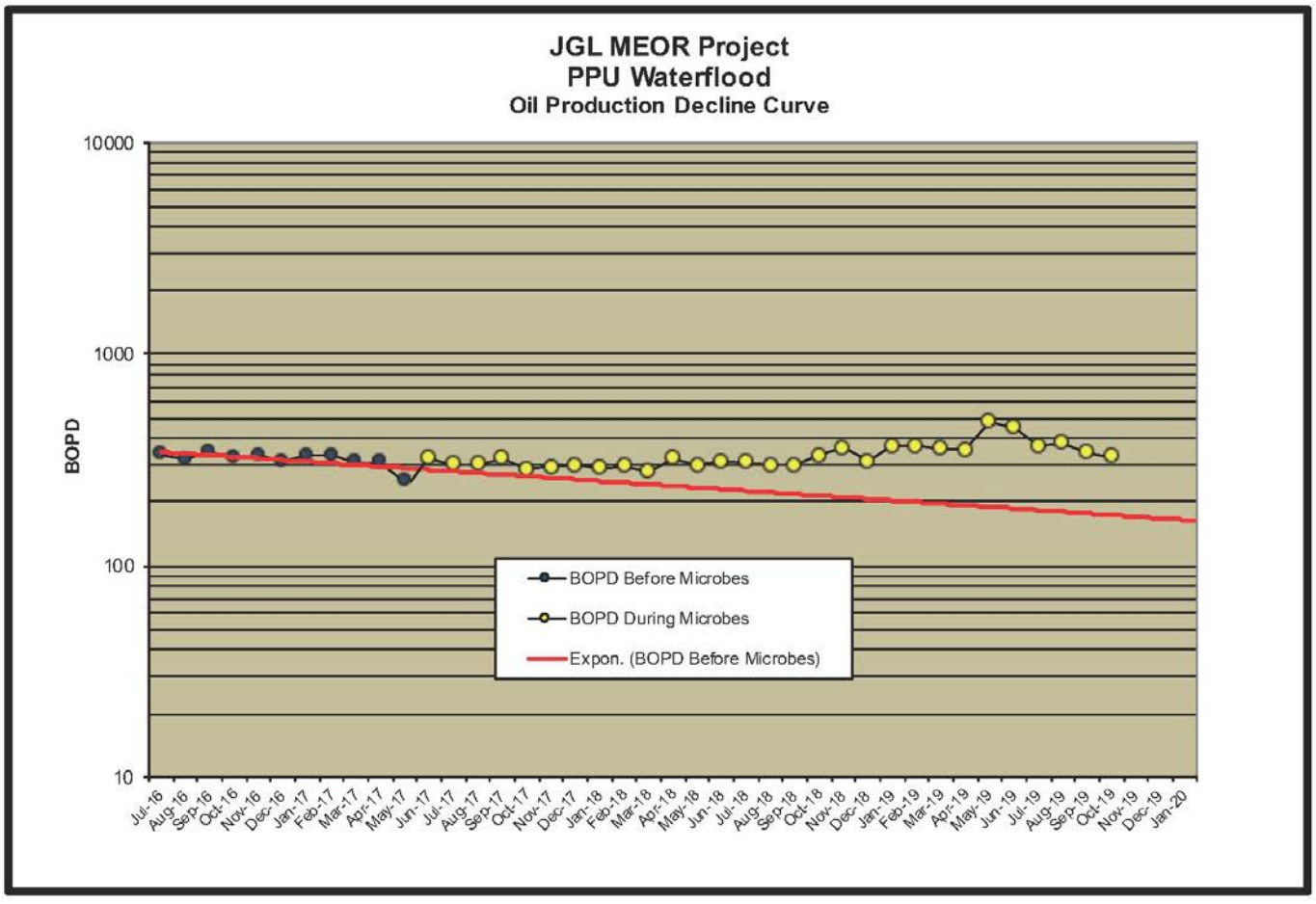
Cleaning tank bottoms also reduced the amount of debris caught in flow lines and pumps. Previously, this debris damaged mechanical seals on transfer pumps and scarred valves in the producer's triplex pumps, **resulting in a 40% reduction in pump repairs. It has also decreased flow line repair and replacement costs by 50%.**

The reduction of residual hydrocarbons throughout the system has decreased the operator's hot oiling expenses by 66% at both waterflood and SWD injection sites.

In the Field - Case History

Microbial Enhanced Oil Recovery (MEOR)

The operator made other changes in their waterflood, such as converting marginal wells into injectors, so their production results were in flux already. **But they reported seeing a significant increase in production that was not attributable to any uplift or stimulation workover.**



The chart above highlights the projected decline curve (red line) before the use of microbes and the actual production realized from JGL's microbial process (yellow dots).

Conclusion

As producers increasingly hear investors asking for cash flow and environmental results, the benefits of microbial remediation become clearer. Microbes have been shown to reduce or eliminate chemical costs, slash repair and workover expenses, and boost production in waterfloods.

Microbial programs in waterfloods have the added benefit of qualifying for state and federal severance tax reductions in many places. These credits have various requirements and may be reduced or eliminated depending on economics or other conditions.

Even without tax credits, microbial remediation offers a number of advantages over chemical and hot oiling treatments in reducing the costs of controlling paraffin/asphaltenes, remediating scale, and corrosion in waterfloods and SWDs.

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