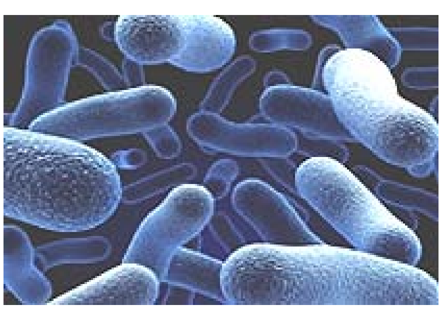
Remediating Frac Water with Microbes and Dissolved Oxygen

One of the stated goals of the frac industry is to be able to remediate and recycle frac water as many times as possible before it has to be disposed. Ideally, the recycling process would continue indefinitely or until the water evaporated through natural means. The expressed desire of the industry is to have a low tech, low cost, straightforward method of remediation which does not require the use of PhD scientists turning knobs on high-tech machines.

There is no shortage of companies offering methods for recycling frac water. Not only are these companies in cost-competition with each other, they each are competing with the cost of fresh water and the attendant costs of water transportation and disposal.

The frac industry at large is growing in its awareness of two methods of low cost water remediation that are commonly used in other industries. These methods employ the use of dissolved oxygen and/or the addition of microbial inoculums. Numerous studies have shown that contaminants in frac water can be remediated to varying degrees by these same low tech methods.



Microbes and dissolved oxygen each can remediate contaminants in frac water, but they work through different pathways. Simply stated, microbes can "digest" certain contaminants, turning them into carbon dioxide gas which escapes harmlessly. Dissolved oxygen takes more of a "chemical" approach in that it can combine with certain constituents in frac water creating new, less harmful compounds. However, as effective as each method is alone, it is the combination of the two which can produce dramatic results.

The microbes of interest are aerobes (i.e. "air breathing" microbes). To live and reproduce to any significant degree in frac water, these aerobes need copious amounts of subsurface dissolved oxygen. The best method for introducing dissolved oxygen into frac water is by a mechanical device referred to as a self-aspirating aerator. This class of aerator has many advantages over conventional means of aeration as listed below.

- **Paddle-wheel** aerators thrash the water and introduce large diameter air bubbles which escape too rapidly into the air. The bubbles often are far too large to be of significant benefit to microorganisms.
- **Ceramic diffuser** aerators are notorious for having emitters that clog quickly. Plus, such aerators cannot disperse the dissolved oxygen as rapidly as is needed in a frac pit.
- **Fountain-type** aerators, sometimes called splash aerators, attempt to capture dissolved oxygen by throwing water into the air. This method is highly inefficient compared to self-aspirating aerators which inject air into water. It takes less energy to move air than to move water.
- **Venturi-type** aerators generally have a low dissolved oxygen transfer efficiency. Plus, most of these aerators are driven by submersible pumps in which the impellers can become clogged with debris. Even if a grinder pump is used, the small throat in the venturi can become clogged.
- **Laminar flow** aerators use small air pumps to pass air through special, low-clogging ceramic-type blocks placed at the bottom of a body of water. They constantly turn the water over from bottom to top, letting surface air

mix with the water. Though the method has merit, it only works when the water is 15 to 20 feet deep or more.

- **Self-aspirating** aerators overcome many of the shortcomings of the above aerators. First, they inject into the water a plume of dissolved oxygen with particle sizes so small that it appears as if an underwater cloud is being formed. Second, they create a gentle, yet noticeable current which disperses the dissolved oxygen throughout the pit. Third, they are much less apt to become clogged, thus avoiding costly downtime. Fourth, they do not unduly roil either the surface or the bottom of the pit, thus avoiding surface foaming and too rapid agitation of settled contaminants.

  There are two types of self-aspirating aerators in the marketplace. The aerator offered by FracCure uses a state-of-the-art turbine which combines the physics principles of precession and centrifugal force. It has one of the highest oxygen transfer efficiencies of any aerator in the market regardless of type. Competing self-aspirating aerators, which do not use a turbine, are said to experience bearing failure in as little as six months. They also tend to create a current so strong that there is concern that it will unduly scour the pit liner.

CONTACT TIME

When frac water is aerated, the overriding issue is contact time between the dissolved oxygen and the contaminated water. The longer the contact time, the greater the remediation. In pits where the water flow-through rate is extremely high, as expressed in barrels per day, it is imperative that the aerators of choice are pumping huge amounts of dissolved oxygen into the water. If poor performing aerators are used, as described above, then the efficiency of the whole remediation process falls short. While this lack of efficiency can be overcome somewhat by employing more aerators, these added aerators increase the operating costs and the potential for downtime. In any event using more aerators of poor performance is not a practical solution.

Another issue in frac water remediation is the trade-off between *gross air transfer* into the water, expressed as liters per second, and *dissolved oxygen transfer efficiency*, expressed as pounds of O2 per horsepower hour (lbsO2/hphr). Gross air transfer refers to the volume of air being injected into the water, regardless of particle size. A huge paddle wheel aerator, for example, might boast a very large air transfer rate. Such boasting is meaningless since the air bubbles often are too large to be of real benefit.

Dissolved oxygen transfer efficiency in lbsO2/hphr is determined by a complicated measurement that attempts to put all aerators on the same scale for comparison. For example, Aerator A might put twice the dissolved oxygen into the water as Aerator B. However, Aerator A might have five times the horsepower of Aerator B , so the comparison is not accurate. By having each class of aerator go through a dissolved oxygen transfer efficiency test, it becomes easier to make side-by-side comparisons.

The FracCure aerator has a gross air transfer rate of up to 17 liters of air per second. Its dissolved oxygen transfer efficiency can range from three to five pounds of oxygen per horsepower hour depending upon the motor size and turbine depth. The FracCure aerator became the subject of webbased physics forums in the recent past, partly because of its remarkable performance.

While dissolved oxygen alone can be helpful in a frac pit, its role in supporting aerobes is even more critical. Given the (symbiotic) relationship between aerobes and dissolved oxygen, it makes sense to combine these two constituents in frac water remediation. While naturally occurring microbes are of value, the remediation process can be jump started by injecting a blend of carefully selected, cultured, waste-specific microbes into the frac water. This designer blend contains a host of (naturally occurring, non-genetically modified) aerobes, each known to address certain contaminants in the pit water.

The combination of dissolved oxygen and a microbial blend makes even more sense when flow-through rates are high in a given pit. In such cases there is a need to ramp up the remediation process quickly and keep it proceeding at a high rate to offset the short contact time with the water.

Given the increasing scrutiny by regulators and the public alike, and given the growing scarcity and cost of fresh water, it is becoming more imperative than ever that frac water be recycled safely and affordably. A combination of dissolved oxygen and a microbial blend can provide a low cost, low tech means of achieving this goal.

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