

Soil Remediation using Hydraulic Fracturing

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ABSTRACT

Hydraulic fracturing, a technology initially developed for oil and gas production, has emerged as a valuable tool in environmental remediation. This article explores the use of hydraulic fracturing for enhancing soil and groundwater cleanup processes by improving permeability in low-porosity soils and bedrock. The process involves injecting a pressurized slurry to create fractures, which are then kept open with proppants to facilitate treatment methodologies such as pump and treat, vapor extraction, and biosparging. Two primary applications, soil fracturing and bedrock fracturing, are discussed, highlighting their unique approaches and benefits in improving contaminant removal. The article also addresses the composition and role of fracturing fluids in maintaining environmental safety during remediation operations. By increasing permeability and enabling efficient access to contaminants, hydraulic fracturing serves as a critical tool for advancing in-situ environmental remediation techniques.

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Introduction

Environmental remediations are considered to be those initiatives that aim at removing pollutants from various media of the environment, such as surface water, underground water, and soil. Hydraulic fracturing is deemed to be a well-stimulation approach, which involves the fracturing of rocks with an aid of pressurized liquid. It follows that hydraulic fracturing is comprised of the techniques that are identified with the facilitation or creation of the openings in the bedrock, as well as soil with lesser porosity. This is mainly done to help the clean-up methods for soil and groundwater to work effectively. The enhancements provided through the environmental fracturing are sometimes referred to as secondary porosity fractures or joints. It therefore, follows that the environmental fracturing is essential in making specific treatment technologies, in the form of pump and treat (P&T) that are essential when it comes to environmental remediation. Soil fracturing and bedrock fracturing are two commonly used hydraulic fracturing technologies.

Hydraulic Fracturing as a Remediation Technology

Previously, hydraulic fracturing technology was mainly utilized in the oil and gas manufacturing industry as a tool for facilitating permeability, as well as enhancing the process of producing oil and gas. However, the usefulness of this technology has since been extended to various environmental remediation processes, where it is effectively used to increase the permeability of the low permeable soils and aquifers [1]. Apparently, hydraulic fracturing is essential as far as contaminant elimination is concerned, hence utilized in various in-situ remediation methodologies. These in-situ remediation processes include vapor extraction and biosparging. Other methodologies, such as pump and treat, as well as dual phase extraction and bioventing, are known in-situ methodologies that apply hydraulic fracturing technologies. Without enhancement of the soils or aquifer's permeability, implementation of in-situ remediation is difficult.

It is apparent that hydraulic fracturing is mainly used in the formation of the zones of higher permeability, not only above the water table but also below, in soils and bedrock. Hydraulic fracturing involves the injection of the slurry into a specified borehole until the realization of a given critical pressure value is achieved. This will prompt the beginning of the fracturing operation [1]. After initiating the process of fracturing an identified opening, the high pressures of the slurry will make the fracture continue to grow out from the borehole. The fluid (slurry) used in the hydraulic fracturing process is essential when it comes to conveying the granular solids to the fracture, as well as initiating and propagating the fracture. The solid granular materials carried to the fracture are known as proppant, and they are useful when it comes to holding the fracture open once the pressure has been released.

More often, the fracturing liquid used in the hydraulic fracturing is formed through the mixture of the guar gum and water, which is called a gel. The use of guar gum is paramount since it increases water viscosity. Crosslinkers, which are tiny inorganic ions, are included in the gel thus increasing the viscosity of the liquid by linking polymer chains [2]. Increasing the viscosity of the fluid used in the hydraulic fracturing is crucial since increased viscosity enables the proppant to remain suspended when pumping is done at low rates. The fracturing liquid is considered to be chemically inert, thus alleviating the fear of further contamination of the soil of the environment during the process of the hydraulic fracturing.

Soil Fracturing

Soil fracturing is mainly used to facilitate in situ remediation characterized by low permeable soils. Soil fracturing technologies aim at placing different granular materials into a designated region, such as the subsurface of the soil. The process of soil fracturing is implemented through the pumping of the fracturing fluid at an

average speed of 22 gallons per minute [2]. Due to the low rates used in pumping the fracturing liquid in the soil fracturing process, it is imperative to incorporate a guar gel with the crosslinker, to enable the suspension of the proppant during fracturing. Soil fractures are mostly designed horizontally; however, fractures are likely to be altered in respect to soil stress conditions. The fracturing process leads to the formation of a single parting, a single fracture of the original host rock. Injections done at various depths of the borehole are vital to the creation of several, layered fractures.

Wells that have been utilized in the fracturing process can be constructed by directing the casing into a specified undersized borehole. This can also be achieved by filling the annular space that exists between the borehole and the casing through the use of cement [2]. After the completion of the soil fracturing, the casings that have been cemented can be left in place, consequently acting like remediation wells. Access to any given fracture should be enhanced as a way of providing versatile options for treatment systems, since extraction and injection can be done with great ease.

Bedrock Fracturing

This technology embraces the use of the procedures employed in the extraction of gas and oil. The improvement of the liquid flow by fracturing is known for enhancing the production of oil and gas. The same procedures can be utilized to recover the fluids and vapors that can, in turn, be used in environmental remediation [2]. The creation of the hydraulic fractures for bedrock is similar to the soil fracturing process. However, unlike in the soil fracturing where low pressures and fluid rates are used, in bedrock fracturing, higher pressure, and higher fluid rates are applied to create fractures. In bedrock fracturing, the process can be completed without the use of proppants. Although it is essential that proppants are used to prevent closure or the healing of the fractures, thus hindering fracturing.

It is apparent that hydraulic technologies play a crucial role in environmental remediation. Soil and bedrock fracturing are two methodologies associated with hydraulic fracturing technologies. These procedures are essential to enhance the permeability of the soils. Hydraulic fracturing is also utilized in the creation of sand-filled fractures, thus improving soil vapor extraction in soils with low permeability. It, therefore follows that hydraulic fracturing is a critical tool for environmental remediation [3].

References

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