

Emerging Technologies for Soil Remediation of Hydrocarbons

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The development of techniques for remediation of polluted soils contamination is gaining global attention. Different remediation technologies can be applied to solve the problem of contaminated soil. The treatments are divided in three groups: biological, physical and chemical. Biological treatments involve the pollutant biodegradation by living organisms; physical treatments are based on the removal of the pollutant through physical means; and chemical treatments refer to the application of agents to promote the pollutant extraction. Moreover, these methods can be *in situ* when they are carried out without removing the soil or *ex situ* when the contaminated soil is treated in other place.

One of the most typical pollutants is total petroleum hydrocarbons (TPH) since they are commonly found in different types of areas due to possible leakage of gasoline, motor oils or diesel fuel. Then, they must be removed to avoid ground water contamination.

Balasubramaniyam [1] used the phytoremediation to remove hydrocarbons, specially PAH's and observed that plants enhance the degradation of petroleum hydrocarbons in soil, since petroleum hydrocarbons can serve as primary growth substrates for bacteria. Other technique that has been used recently to remove TPHs is electro kinetic remediation [2,3] in which two electrodes are implanted in the soil and a direct current is applied with the aim of ionic species and charged particles migrate toward one electrode. Nevertheless, electro kinetic treatment results more efficient with metals and charged pollutants than organic pollutants.

Another study carried out by Zhang [4] studied the effect of ultrasound on remediation on the same type of pollutants and they found that ultrasonic treatment can significantly promote the reduction of TPH in soil. Moreover, this technique has been effective in the removal of PAH's [5]. This can be due to the fact that ultrasonic waves increase the soil porosity accelerating the desorption and provoking the removal of pollutants. Moreover, Feng and Aldrich concluded

that ultrasound can not only desorb organic pollutants from soil, but also degrade organic pollutants completely by oxidation [6]. Then, the cavitation produced by ultrasonic irradiation improves the physical desorption, flocculation, and chemical oxidation of pollutants in soil. This technique can be more useful than electro kinetic for the removal of organic contaminants.

The application of ultrasonic can be combined with other techniques, such as solvent extraction or soil-flushing method, to enhance the remediation process and decreases the time of the process [7]. The results obtained by Adegbola showed that sonication can enhance contaminant removal considerably.

This paper presents different promising technologies for the effective remediation of soil contaminated with TPH.

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