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Soil-Water Repellency and Critical Humidity as Cleanup Criteria for Remediation of a Hydrocarbon Contaminated Mud

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The majority of soil remediation programs focus mainly on reducing the hydrocarbon concentration, based on the assumption that the primary impact is toxicity and/or leachates and that these are directly proportional to concentration. None-the-less, interference with natural soil-water interactions are frequently more damaging, especially for sites contaminated with very viscous, weathered hydrocarbons. Therefore, the kind of hydrocarbons present in the soil and their interactions with soil surfaces may be more important than the overall hydrocarbon concentration in terms of soil restoration. One recently patented technology, the Chemical-Biological Stabilization process, focuses specifically on restoring soil fertility as the main objective for remediation of sites with agricultural use. This method was recently validated at an industrial scale by the treatment of 150 cubic meters of bentonitic drilling muds (70,5% fines) from an old sulphur mine, which were contaminated with very weathered oil (4º API), consisting of 31% asphaltenes. This material was treated by adding 4% (w/w, dry) of calcium hydroxide, followed by 4% (w/w, dry) of sugar cane cachasse (a fine fibered agricultural waste), thoroughly mixing between additions using an excavator. After the soil had dried sufficiently and the pH was <8, a fine-rooted, C-4 tropical grass (Brachiaria humidicola) was planted by seed. Over a two year period this material was monitored for several factors including field moisture (%H), field capacity (FC), and soil water repellency. MED was measured on air dried soil and WDPT values were calculated from the extrapolation of penetration time vs. ethanol molarity functions (Rx=0,99). Additionally, water penetration times were measured at different humidities to determine critical moisture levels for absorption in <5s and <60s. Initially, the FC increased from 24,9%H to 33,8%H (in 4½ months), probably due to the addition of the organic amendment. Over the next 6½ months, the FC dropped to 25,6% H, likely due to organic matter decomposition. However, during the following year+ (13½ months) the FC increased to 33,8%H probably due to an increase of soil humic substances while a vigorous vegetative growth was established. During two years of treatment the MED values were reduced 30% from 5,13 to 3,58M, and WDPT values were reduced over 25 times (from 10 exp5,6 s to 10 exp4,2 s). Critical humidity values varied from $\sim$16,9 – 19,5%H for penetration in <5 s and from $\sim$15,1 – 15,5%H for penetration in <60 s, in both treated and untreated material. During the driest part of the year, in May before the first rains, the soil humidity was 20,3%, and thus values below the critical levels were not experienced. This permitted the development of a complete vegetative cover, vigorous growth, and transformation of a geologic substrate (bentonitic drilling muds) into a soil-like material apt for agricultural use. This focus on soil-water relationships and the use of soil fertility parameters in general is important in establishing cleanup criteria for the real remediation of hydrocarbon contaminated sites in agricultural areas. As seen in this study, relatively high WDPT and MED values may not necessarily indicate soil moisture problems and these need to be complemented with actual site information on soil humidity during the annual cycle and with determinations of critical humidity. Additionally, the augmentation of field capacity using organic conditioners may effectively mitigate potential critical humidity problems.