



**FORENSIC APPLICATIONS CONSULTING TECHNOLOGIES, INC.**

**SYNOPSIS OF TESTING  
EFFICACY OF DEGRADATION OF  
TOTAL PETROLEUM HYDROCARBONS BY  
TERRA FIRMA®**

During the spring of 2010, Forensic Applications Consulting Technologies, Inc. (FACTs) brokered an independent evaluation of the American Cleaning Technologies, Inc. product known as Terra Firma.®

The testing was performed by Huffman Laboratories of Golden, Colorado. Huffman Laboratory has been providing independent analytical and testing services since 1936. During the evaluation process, to ensure the integrity of an objective evaluation, American Cleaning Technologies was prohibited from communicating with Huffman Laboratories, and all technical aspects of the test were exclusively determined by FACTs and Huffman Laboratories. American Cleaning Technologies, Inc. was only permitted to provide instructions on the recommended field application quantities of Terra Firma.®

Terra Firma® was applied to a soil obtained by American Cleaning Technologies from the oil fields of Kuwait. The soil was extremely heavily contaminated with crude oil, containing approximately 24% crude oil by weight. The multiple batch samples were simultaneously incubated, and later, pair matched based on original weight. The test ensemble included controls and blanks, and all results were blank corrected and control corrected to eliminate any statistical artifacts.

The tests were conducted in an environmental test chamber designed to maintain steady-state conditions. The environmental test parameters were established to mimic daytime Kuwaiti outdoor temperatures and humidities. The environmental test chamber was maintained at 52°C (+/- 2°C) and 48% RH.

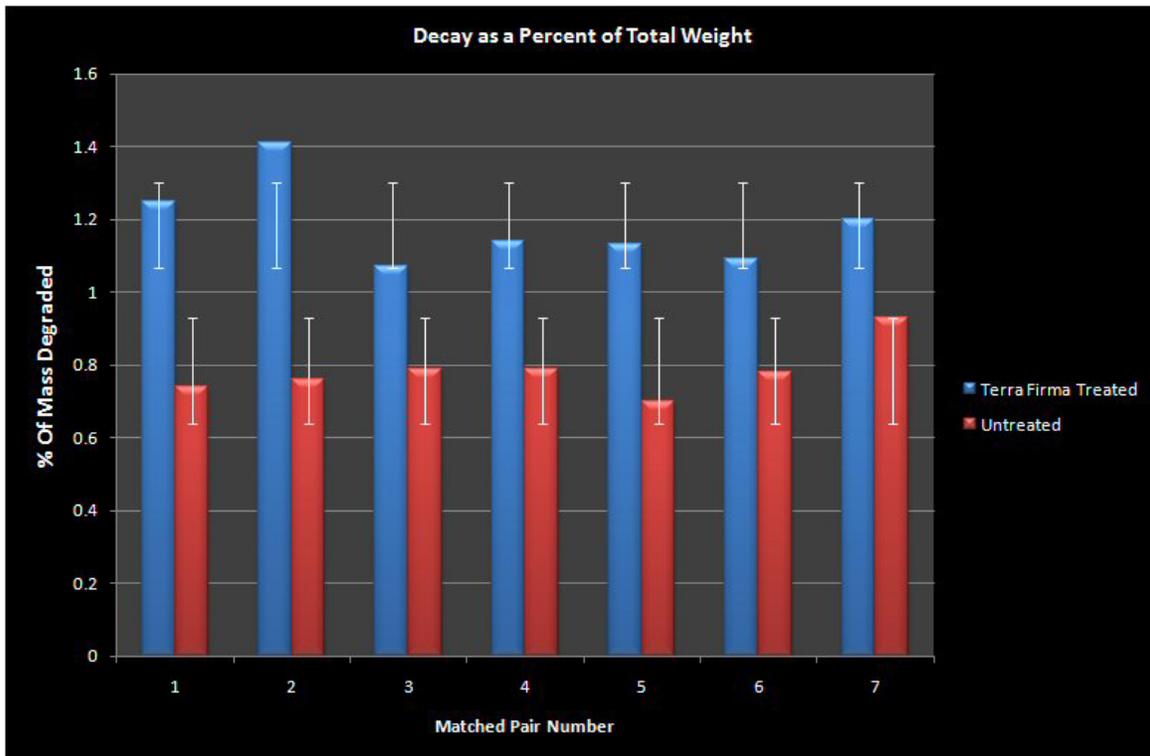
Degradation was determined on an absolute blank/control corrected loss-of-mass basis during the 46 day test period and was control-corrected with matched controls and laboratory blanks.

A typical remediation time would be measured in years; however, this test period was restricted to a matter of only 46 days. Therefore, to account for the very short time period available for the test, the application rate was increased to an equivalent of three and one half tons of product per acre of contaminated soils. The product was applied dry and no water was used in the application.

After 24 days of incubation, American Cleaning Technologies stated that the application of the product would include some kind of surface agitation and addition of a second application of product. Therefore, tare-controlled and humidity conditioned Teflon® stir rods were used to stir in the second application which doubled the product quantity.

Over the course of the test period, a statistically significant difference emerged in the loss of mass between the treated and untreated soils. FACTs matched the samples into

control and treated pairs based on original sample weights. In the chart below, the cumulative average loss between the two data sets (treated and untreated) is presented.



**Chart 1**  
**Total Cumulative Percent Weight Loss**  
**Matched Pair Side-by-side Comparison**

A statistically significant difference between the matched pairs emerges when the decay is expressed as a percent of weight loss, (the lower confidence interval of the treated samples is greater than the upper confidence intervals of the untreated sample.) The error bars represent 2 standard deviations of the Gaussian distribution of the cumulative loss. An ANOVA analysis indicated that the mean equality is rejected, and the observed differences are not likely to be due to chance alone.

The rate of loss over time exhibits a trend expected of other microbiological systems wherein there is a “lag phase” (a genetic response to a new environmental condition), and a “growth phase” (wherein the microorganism has adopted to the new environment).

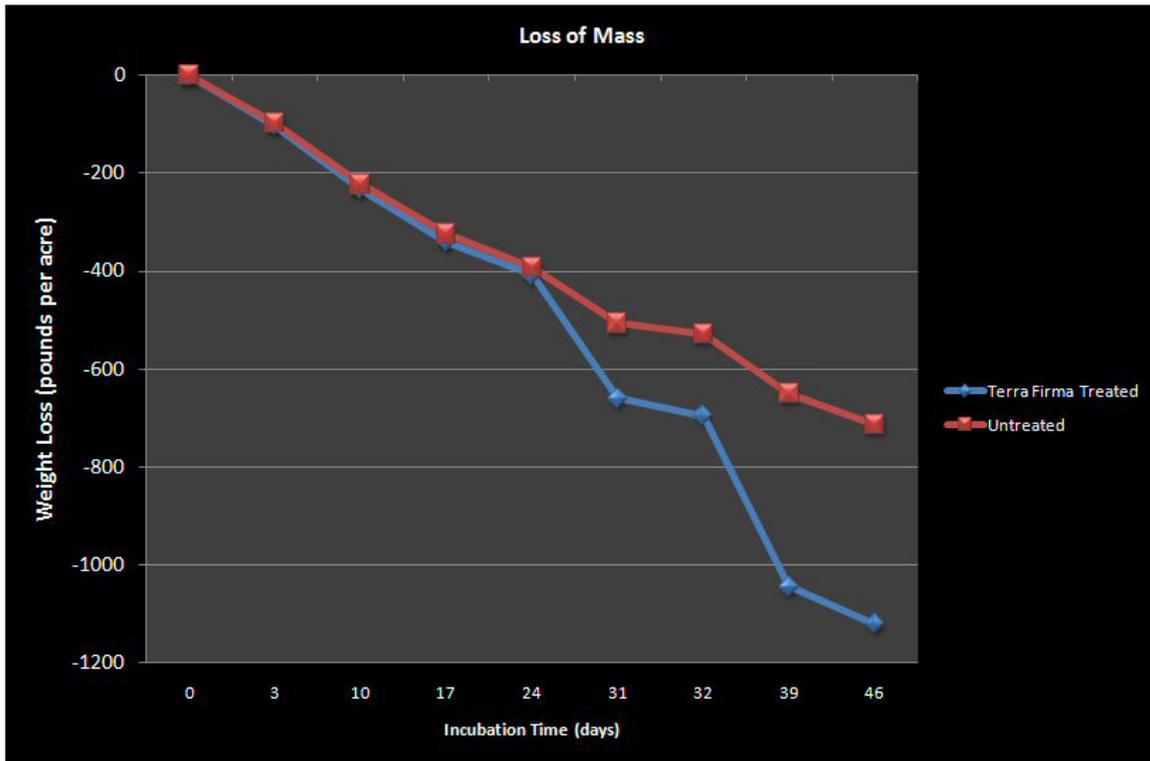
It is possible that once the culture becomes accustomed to the new environment, a “cryptic growth” phase would be observed wherein the culture would be in dynamic equilibrium between death of organisms and new growth.

Agitation on the 24<sup>th</sup> day appears to have “kick started” the organisms or promoted some other mechanism to greatly speed up decay of total petroleum hydrocarbons.

Given the environmental conditions, the crude contaminated soils appear to be in a rate limited decay (presumably due to photodegradation and gross volatilization) and loses about 16 pounds of total petroleum hydrocarbons per acre per day (equivalent to about 17 kg TPH/hectare/day).



By comparison, the Terra Firma® treated soils lost approximately 24 pounds of total petroleum hydrocarbons per acre per day (27 kg TPH/hectare/day).



**Chart 2**  
**Total Cumulative Weight Loss in Pounds Per Acre Per Day**

The trend lines indicate that the *rate* of loss in the untreated soils remains the same (the slope is the same at all points  $t$ ), whereas the *rate* of loss in the treated soils is *increasing* with time (the degradation slope is steeper with increasing  $t$ ). The data suggest that after 46 days, the process had not yet reached its maximum rate of loss, and that as time increases, the rate of loss will similarly increase.

This test was performed under specific, controlled conditions using a specific and single formulation. Each remediation site presents its own unique environment and contaminant profile. The results observed during this test may not be indicative of all locations and contaminants.

Sincerely,

Caoimhín P. Connell  
Forensic Industrial Hygienist

