

## Terramend® Reagent Application Guidelines – FAQs

### HOW DOES THE TREATMENT PROCESS WORK?

The soil may be treated in situ or ex situ. Large debris or objects (greater than 6 inches) that may impede the soil tilling and mixing process should be removed. Terramend® treatment is typically conducted by thoroughly mixing Terramend® into the soil, adjusting the moisture content, and conducting regular soil mixing to enable oxygen penetration into the soil. For in situ or ex situ soil treatment to depths of up to 2 feet (or in windrows), Terramend® is tilled into the soil and water is added to achieve the target moisture content. The soil is then tilled frequently (2 to 3 times per week at the outset for high hydrocarbon soils, and then weekly in the last half of the expected treatment duration). Soil moisture content and pH are monitored regularly (at least once every two weeks). For thinner soil layers (<8 inches), less frequent mixing/tillage may be required because oxygen can diffuse sufficiently far into the soil matrix. In these cases, tilling of once per week may be adequate.

### WHAT SOIL CHARACTERISTICS ARE REQUIRED TO ENABLE USE OF THE TECHNOLOGY?

Most soils can be remediated effectively with Terramend® reagent. Terramend® has been successfully applied to soils with a wide range of physical and chemical properties, including wide variations in soil texture (i.e., sand/silt/clay content), organic matter content, and pH (from about 5.5 to 8.5). Even relatively saline/sodic soils have been effectively treated. Non-soils may also be treatable, but results are much less predictable. A number of successful Terramend® applications have also been conducted on dredged sediment and industrial process wastes. On occasion, we have worked with soils that have high bioavailable arsenic and/or cyanide concentrations that may impede the biotic treatment component. Where this is suspected as a potential problem, some relatively simple biological activity testing may be conducted.

### HOW LARGE SHOULD A PILOT TEST BE?

Pilot tests may range from a few cubic yards with a manually operated roto-tiller to several hundred cubic yards implemented with full-scale equipment. Larger pilots better mimic the full-scale equipment and conditions to be used.

### WHAT EQUIPMENT DO YOU RECOMMEND FOR TILLING AND MIXING THE SOIL?

Specialty agricultural tillage implements are recommended and are available for rent from Evonik. The tillers are capable of thoroughly mixing soil to a depth of 2 feet, making them well-suited to effectively treating large areas either in situ or ex situ. Proper soil mixing using these tillers is an essential part of the treatment process. In terms of tilling rate and equipment needs, the tillers can each till approximately 2 acres per day in the very low gear (creeper gear) required for good mixing and to avoid damage to the machine. Other equipment that we have successfully used includes deep soil spaders from Imants.

The Imants spaders can mix soil to depths as great as 56". Typical excavators are not generally recommended for soil treatment, as a great deal of care and time will be required to get the very thorough mixing that is needed. If an excavator is the only available option for soil mixing adequate time should be used and/or some of the excavator bucket mixing heads from ALLU or others should be considered.

### **WHAT ABOUT DEEPER SOILS AND SOIL THICKNESSES?**

These may be treated ex situ or in lifts. Deeper soil mixing equipment from ALLU, Alpine, and others may be suitable for deeper soil applications; however, the economics of repeated mixing of soils can increase cost.

### **WHAT TREATMENT REMOVALS DO WE ANTICIPATE?**

The rate at which aerobic soil treatment proceeds is strongly influenced by soil type, contaminant chemistry, mixing/tillage frequency, and temperature. Removals of 95% to 99% are achievable for most compounds. Lower molecular weight compounds such as gasoline range organics (GRO) and diesel range organics (DRO) - the lighter hydrocarbons, both aliphatic and aromatic, are more rapidly degraded. Higher molecular weight compounds such as oil range organics (ORO) and some PAHs are degraded more slowly. Treatment times range from a few weeks to a few months in most cases. Oil range organics (ORO, or those >C29) take more time to treat because of lower solubility and bioavailability. For phthalates, chlorinated phenols, and aerobically degradable pesticides treatment times vary considerably depending on starting concentrations and remedial goals. Ask us for an estimate specific to your site by providing basic data on our Site Evaluation form.

### **ANY SPECIAL CONSIDERATIONS FOR CLAY SOILS?**

Clay soils can be challenging to work when wet, and it is important that the tilling and mixing processes enable breaking up of soil structure (i.e., large aggregates). Thus, in wet environments, additional time may be required for drying, or the soil may need to be treated ex situ or be covered to prevent entry of too much rain thereby maintain good handling qualities and supporting maintenance of aerobic conditions.

### **CAN YOU PROVIDE US WITH TESTING AND SAMPLING PLANS?**

We are happy to provide project-specific guidance to support development of effective sampling and monitoring plans. Sampling requirement for regulatory acceptance are generally driven by local regulatory agencies. Accepted sampling requirements can range from one sample per each 100 – 200 tons of soil up to one sample per surface area of ¼ acre or more.

### **WHAT ABOUT TREATMENT PROCESS TEMPERATURE?**

Warmer air temperatures (daily highs of 20°C or more) support more rapid completion of treatment. This relates, of course to warmer soil temperatures (above 15°C); however, we have worked successfully in northern Canada by timing the work for the warmest part of the season, covering, and even heating soil.

### **HOW IMPORTANT IS SOIL MOISTURE CONTENT?**

Excessive soil water content will slow the treatment process by restricting oxygen flow into the soil by diffusion and by making aeration by mechanical mixing/tillage less effective. When soil water content is too high anaerobic conditions will develop and aerobic biodegradation will be inhibited. Conversely, when soil moisture is too low much of the contaminant will not be accessible to the soil's microbial population and the rate of treatment will be reduced. The soil moisture content should be kept between 50% and 60% of water holding capacity (WHC). Establishing and maintaining soil moisture content in this range is essential to effective aerobic biodegradation of the target compounds and rapid completion of treatment. Short excursions either above or below the optimal range are common but need to be corrected or the treatment progress will suffer.

### HOW IS WATER DELIVERED/SUPPLIED IF THE SITE IS DISTANT FROM A WATER SOURCE?

Many methods may be used, including spray irrigation systems with sprinklers, drip irrigation systems, and the addition of water using tanker trucks. If water is particularly scarce, it may be useful to cover the soil to limit evaporation. It is important to add the water slowly to avoid ponding and allow for slow infiltration.

### HOW MUCH WATER IS REQUIRED?

This is very site and soil-specific. The target moisture content is 50% – 60% of the soil's WHC. Thus, both the initial moisture content and target moisture content must be known. The target is determined through a WHC test, which can be conducted in a very basic portable field laboratory (scale, microwave, and some other basic supplies). Factors including soil texture (i.e., sand/silt/clay content), temperature, wind, and treatment time will influence the total water requirement.

### WHAT ARE THE WATER QUALITY REQUIREMENTS?

The general recommendation is to use that water that is suitable for growing vegetable crops. Seawater and excessively brackish water are unlikely to be suitable.

### HEALTH AND SAFETY

When working with Terramend®, the use of standard personal protective equipment (PPE) is recommended, including safety glasses, steel toe boots, nitrile gloves, hearing protection (when needed), and hard hat. Dust mask is recommended when in close contact with Terramend® under certain conditions. Use of goggles or a face shield is recommended when splash hazards are present. Please consult the Terramend® reagent Safety Data Sheet for guidelines regarding proper handling procedures.

For some target compounds higher level PPE may be appropriate. The correct PPE for use during any remediation project is influenced by site conditions and contaminant characteristics. An appropriate Health & Safety Plan should be developed for each project and followed by all persons entering the project site.

Please contact Evonik for additional guidance.

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