ARCHIVE: **Archived to revise and clarify the guidance within the document and because revisions made to VAP rules in 2002 in OAC Chapter 3745-300 render inaccurate the rule citations in this document (technical content remains accurate under the 1996 VAP rules). Refer to VA30007.03.019 for the updated document.**

TITLE: **Recommendations Regarding the Sampling and Analysis of Fraction Organic Carbon (f_{oc}) in Soils**

DATE EFFECTIVE: March, 2000

KEYWORDS: Soils, organic carbon, property-specific, sampling

RULE: OAC 3745-300-07

QUESTION: **In terms of sampling and analysis, how should a Certified Professional (CP) evaluate a property for fraction soil organic carbon?**

ANSWER:

Introduction

The fraction soil organic carbon (**f_{oc}**) is a weight measure of the amount of organic carbon relative to its soil media. Sources of organic carbon in the soil include degraded forms of raw organic matter such as crop or plant residues, which have undergone some physical or chemical degradation from detritovores, herbivores, and microbial decomposers. This alteration of organic matter leads to products such as humus, a refractory source of organic carbon. Since organic carbon compounds have the potential to chemically bind certain contaminants, the **f_{oc}** parameter is used to estimate the capacity of a soil to adsorb or bind certain contaminants. In most undisturbed soils there will be an inverse relationship between depth and carbon concentration. Thus, it is important to have **f_{oc}** data determined from soil samples that are representative of site characteristics and the particular application of the **f_{oc}** data. Although the VAP does not presently prescribe an established protocol for determining a property-specific **f_{oc}** value, a discussion of what might constitute best professional practices follows.

Sampling protocols and considerations

There are several complicating factors that affect the determination of **f_{oc}** at VAP sites. Many VAP sites will not have a true organic layer, since such sites have had a long history of industrial or commercial

land use. However, if the site does possess an organic layer or previous or present vegetative cover, some stratification in sampling is recommended. The VAP does not recommend that the organic layer, with its typically high organic carbon concentrations, be used to wholly represent conditions for any or all soils at the site. This would result in an overestimation of the soil's ability to provide a sink which can potentially bind certain contaminants. If vegetative litter is present at the soil surface, then for most applications, the VAP recommends taking a core sample that extends from 15 cm below the soil surface to a depth just below the mean annual depth to the water table. This sampling should be repeated to an extent such that the total number of samples reflect topographic variation and other features of the site.

At many VAP sites, fill materials have been introduced to disturbed soils due to grading, excavation and other activities including remediation. Fill materials are sometimes composed of slag, foundry sand or demolition debris, that typically have no significant organic carbon content. It is also possible that previously-vegetated fill may be located (through grading or fill placement) at varying intervals throughout the subsurface. This addition of non-native material, or the alteration or removal of native soils may affect the depth distribution of soil carbon.

Because of the variability of the distribution of soil organic carbon among VAP properties, a single sampling protocol cannot be generally applied to all sites. Thus, sampling for $\mathbf{f_{oc}}$ should be of a sufficient number to be representative of the soils of interest at each property, based on the heterogeneity as determined from an assessment of initial soil borings or excavations.

If the $\mathbf{f_{oc}}$ value is to be used for a Property-specific leaching evaluation, then a mean value representative of the thickness of the unsaturated zone (and therefore not a value derived solely from surface soils) should be determined.

In the case that the Property-specific $\mathbf{f_{oc}}$ is measured for the purpose of determining a Property-specific soil saturation concentration (which may be done with the use of generic direct contact soil standards as described in Paragraph (B)(3)(f) of Rule 3745-300-08 of the OAC), then an $\mathbf{f_{oc}}$ value representative of the direct contact point of compliance (*e.g.*, 2 feet), as described in Paragraph (B)(2)(d) of Rule 3745-300-08 of the Ohio Administrative Code (OAC) should be used. For situations pertaining to Property-specific soil saturation, the determination of $\mathbf{f_{oc}}$ should be at a location which is not impacted by

releases of organic substances (*e.g.*, petroleum or other organic chemicals of concern). For example, a petroleum release will leave residues which would tend to increase (sometimes considerably) the organic carbon content of the impacted soil above natural levels.

Method of analysis

The ASTM D2974-87 method provides a protocol for the stepwise quantification of measuring organic and inorganic (*e.g.*, carbonates) components of soil carbon. Most of the organic components are burned off at temperatures of 440 degrees Celsius (°C). The most recalcitrant organic forms are liberated above temperatures of 440°C. Finally, around temperatures of 750 °C carbonates are volatilized. A general "rule of thumb" is that a soil with a pH $\leq$7 will contain only trace amounts of carbonates. This is because soil carbonates buffer the soil against acidity. When a soil is leached of or has naturally low concentrations of basic cations and its buffering capacity is exceeded, the soil is predisposed to a pH lower than neutral (7). A sample can be run through one or more steps of the complete procedure to obtain information on both organic and inorganic forms of carbon in a soil sample.

Although the procedure may be performed in a stepwise manner, it is recommended that the analyst conduct the full ASTM D2974-87 procedure and report initial gravimetric soil water content, fraction organic carbon (440 °C), fraction inorganic and recalcitrant organic carbon (750°C), and soil pH measured in a 1:1 soil-water slurry. Since it is the loss on ignition of soil organic matter that is measured, a correction factor must be applied to estimate organic carbon content of the soil. The weight loss on ignition should then be multiplied by a factor of 0.58 (approximate mass (mg) organic carbon per unit mass (mg) soil organic matter); the product is a reasonable estimate of soil organic carbon.

Since the fraction organic carbon is used for determining the potential for contaminants to partition to ground water, Total Organic Carbon (TOC)-Dissolved Organic Carbon (DOC) may also be determined on ground water samples. For example, the fraction TOC-DOC in ground water is commonly used in many ground water flow models to account for the ability of the soil media to retard dissolution of a non-aqueous phase liquid (NAPL) to the dissolved phase. Due to the specific nature of the TOC-DOC analysis, it need only be done when required by the consulting hydrogeologist or the ground water flow model used in the risk assessment. Specific methods of analysis for TOC or DOC in ground water is not covered in this TDC.

SUMMARY: Due to its important role in binding contaminants in soil media, the fraction soil organic carbon can affect the availability of contaminants for partitioning to various compartments in the environment. In order to accurately reflect the fraction soil organic carbon at a property, it is important for the CP to consider the geologic setting of the property, especially in terms of heterogeneity of the soil profile, the presence of hydrocarbons or other sources of organic carbon in the soil, and potential for leaching to ground water. A method which involves "ashing" soil samples is recommended by the VAP for the determination of the fraction soil organic carbon.

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