Designation: D7294 – 06

StandardGuide for Collecting Treatment Process Design Data at a Contaminated Site—A Site Contaminated With Chemicals of Interest[1]

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1. Scope

1.1 This guide lists the physical and chemical treatment processes design data needed to evaluate, select, and design treatment processes for remediation of contaminated sites. This data is listed in Tables 1 and 2. Much of these data can be obtained and analyzed at the site with instruments and test kits.

1.2 It is recommended that this guide be used in conducting environmental site assessments and Remedial Investigations/ Feasibility Studies (RI/FS) and selections of remedy in U.S. Code of Federal Regulations 40 CFR 300.430.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D422 Test Method for Particle-Size Analysis of Soils
D1067 Test Methods for Acidity or Alkalinity of Water
D1293 Test Methods for pH of Water
D1498 Test Method for Oxidation-Reduction Potential of Water
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2325 Test Method for Capillary-Moisture Relationships for Coarse- and Medium-Textured Soils by Porous-Plate Apparatus (Withdrawn 2007)[3]
D2434 Test Method for Permeability of Granular Soils (Constant Head)
D3152 Test Method for Capillary-Moisture Relationships for Fine-Textured Soils by Pressure-Membrane Apparatus (Withdrawn 2007)[3]
D3590 Test Methods for Total Kjeldahl Nitrogen in Water
D3921 Test Method for Oil and Grease and Petroleum Hydrocarbons in Water
D4327 Test Method for Anions in Water by Suppressed Ion Chromatography
D4564 Test Method for Density and Unit Weight of Soil in Place by the Sleeve Method
D4611 Test Method for Specific Heat of Rock and Soil
D4943 Test Method for Shrinkage Factors of Soils by the Wax Method
D4972 Test Method for pH of Soils
D5084 Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
D5334 Test Method for Determination of Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe Procedure
D5463 Guide for Use of Test Kits to Measure Inorganic Constituents in Water
D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Groundwater
D6836 Test Methods for Determination of the Soil Water Characteristic Curve for Desorption Using Hanging Column, Pressure Extractor, Chilled Mirror Hygrometer, or Centrifuge
E953 Test Method for Fusibility of Refuse-Derived Fuel (RDF) Ash

2.2 *Other Documents:*

Remediation Technologies Screening Matrix and Reference Guide[4]
U.S. Code of Federal Regulations 40 CFR 300.430[5]

3. Terminology

3.1 *Definitions:*

[1] This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.01 on Planning for Sampling.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available at http://www.frtr.gov

[5] Available at http://www.gpoaccess.gov/cfr/index.html

TABLE 1 Water Parameters[A]

Technology[B]	DO (field)	Temperature (field)	Total Suspended Solids (TSS)	Turbidity[C]	CO_2	H_2S	Dissolved H_2	Methane, Ethane and Ethene	pH (field)	ORP (field)	Chloride (Cl-)	Fluoride (Fl-)	Ca^{+2}, Mg^{+2}, Mn^{+2}, Na^{+}, K^{+}[D]	TOC	COD	DOC	Total Dissolved Solids (TDS)	Alkalinity HCO_3^-, $CO3^{-2}$	Conductivity (field)[E]	Volatile Fatty Acids	Biological Oxygen Demand (5-day BOD)	Oil/Grease	Ammonia (NH_3)	Phosphorous (total)	Ferrous Iron Fe^{+2}[F]	Total Iron Fe^{+2} + Fe^{+3}[D]	Sulfate/sulfite (SO_4=/SO_3=)	Nitrate/nitrite (NO_3-/NO_2-)	Kjeldahl Nitrogen	Sieve Analysis[G]
IN SITU TREATMENT																														
Phytoremediation[H]	X	X		X					X	X			O				O		X					O				O	O	X
Permeable Reactive Barriers	X	X	O	X		O			X	X	O	O	X	X			O	X	X					O	X		X	O	O	X
Monitored Natural Attenuation	X	X		X	O	O	O	X	X	X	X			X				O	X	O				O	X		X	X	O	X
Enhanced Bioremediation	X	X		X	O	O	O	O	X	X	X			X				O	X	O				O	X		X	X	O	X
Air Sparging	X	X		X		O			X	X				X	O		O	X	X		O			O	X		O	O	O	X
Hot Water or Steam Flush/Strip	See Soil, Sediment & Sludge Parameters—thermally enhanced SVE																													
Slurry Walls	See Soil, Sediment & Sludge Parameters																													
Bioslurping[I]	X	X		X					X	X				X					X											X
Dual (multiphase) Phase Extraction[J]	X	X		X					X																					X
Chemical oxidation	X	X		X	O	O			X	X			O	X	O		O	O	X						O	O				X
In Well Air Stripping	Same parameters as air sparging																													
Free Product Recovery	See Dual (multiphase) Phase Extraction																													
EX SITU TREATMENT																														
Advanced Oxidation (UV)	X	X	O	X		O			X	X	X		O	X	O		O	X	X			X		O	X	O		O		
Bioreactor	X	X	O	X		O			X	X		X	O	X	O	O		O	X		O			O	O		O	O	O	
Air Stripping	X	X		X					X	X			O	X			O	X	X				O		X					
Ion Exchange	X	X	O	X					X	X	O		X	X		O	O	O	X						O		O	O		
Adsorption (carbon)	X	X	O	X		O			X	X			O	X		O	O	O	X			O		O	O					
Precipitation/Coagulation/Flocculation	X	X	O	X					X	X			O	X				O	X			O			O		O		O	
Constructed Wetlands	X	X	O	X		O			X	X	O	O	O	X		O		O	X					O	O		O	O	O	

[A] This table was developed jointly by the U.S. Army Corps of Engineers, Hazardous, Toxic, and Radioactive Waste Center of Expertise and the U.S. Environmental Project—Engineering Forum.
[B] See Treatment Technology Profiles in www.frtr.gov for a description of the technology.
[C] Quality of sampling indicators.
[D] If these cations are to be analyzed in an offsite laboratory, evaluate analyzing all metal as the cost may be the same.
[E] Conductivity is a good indicator of Total Dissolved Solids (TDS).
[F] Analyze for Fe^{+2} in the field or total iron in the laboratory and estimate Fe^{+2} from turbidity, etc.
[G] Estimate of soil hydraulic properties in the aquifer where the samples were taken. This information may already be available.
[H] See soil parameaters for vadose zone.
[I] Easily converted to conventional bio venting system or SVE after free product is removed to complete the remediation. Include bio/SVE parameters.
[J] Dual (multiphase) extraction is generally combined with technologies such as bioremediation, air sparging, bioventing and soil vapor extraction. Include parameters for these technologies if they are being considered

NOTE 1—"X" parameters are recommended during early site investigations before any treatment is being considered or has been selected.

NOTE 2—"O" parameters are recommended in addition to "X" if the technology is being considered or has been selected.

TABLE 2 Soil Sediment and Slurry Parameters[A]

Technology[B]	Temperature	Soil pH	Low Volatile Metals (Sb, AS)	Semi Volatile Metals (Hg, Br, Cr, Na, K)	TOC	Kjeldahl nitrogen	Nitrate, Nitrite	Available P (soil), Total P (water)	Plasticity (Atterberg limits)	Sieve Analysis/(Particle Size Analysis)	Specific Heat BTU/lb	Soil Fusion Temperature	Sodium	Moisture Content	Field Capacity	Bulk Density	Potassium	Soil Permeability	Oil and Grease[C]	Cation Exchange Capacity	Alkalinity (HCO_3-, CO_3^{-2}) (water)	Fe+3, Mn+4 (water)	Oxygen (soil gas)	CO_2 (Soil gas)	Calcium, Magnesium	Soluble Solids (electrical conductivity)	Conductivity (thermal)	Capillary pressure–saturation curve	Strataigraphy[D]	Humic Content	Fluoride, Chloride	Sulfate	Sulfur (total)
IN SITU TREATMENT																																	
Bioventing[E]	X	X			X	O	O	O		X				X	O	O		O				O	O	X				O	X	O			
Soil Flushing[F]		X			X					X				O				O		O			X							O			
Soil Vapor Extraction[E]	X									X				X		O													X				
Thermally Enhanced SVE[E]	X	X			X	O	O	O	X	X	O		X	X	O	O	O	O			O	O			O		O	X	X				
Monitored Natural Attenuation (See water parameters table)																																	
Solidification/Stabilization[F]		X			X				O	X			O	X		O		O	O											O	O	X	
Hot Water/Steam Flushing/ Stripping See thermally enhanced SVE																																	
Phytoremediation[G,H]	X	X			O	O	O	O		X			O	O	O		O	O		O						O					O	O	
Chemical Reduction/Oxidation (See water parameters table)																																	
Slurry Wall & Sheet Piling		X							O	X				O			O	O			O					O							
EX SITU TREATMENT																																	
Composting		O			O	O	O	O		X							O																
Landfarming[H]	X	O			O	O	O	O		X																							
Slurry Phase Biological Treatment		X			X	O	O	O		X							O																
Chemical Reduction/Oxidation		X			X					X				O					O		O									O			
Soil Washing		X			X					X																				O			
Soil Vapor Extraction	X									X				O	O	O		O										O		O			
Solidification/Stabilization (Same as in situ)																																	
Thermal Desorption[I]		O	X	X	O	O	O	O	O	X	O	O		X																O	O		O
Incineration (See thermal desorption)																																	
Sediment Technologies applicable to saturated soils will generally also be applicable to sediments																																	
Biopiles		X			X	O	O	O	O	X				O	O				O			O											

[A] This table was developed jointly by the U.S. Army Corps of Engineers, Hazardous, Toxic, and Radioactive Waste Center of Expertise and the U.S. Environmental Protection Agency Technical Support Project—Engineering Forum.

[B] See Treatment Technology Profiles in www.frtr.gov for a description of the technologies.

[C] Only if visible evidence.

[D] Usually available from geological investigation data.

[E] Vadose zone.

[F] Vadose or saturated zone.

[G] See water parameters table for saturated zone.

[H] Additional data on soil conditioning may be needed to determine the suitability of the soil to support vegetation suitable for phytoremediation.

[I] Includes cement kilns.

NOTE 1—"X" parameters are recommended during early site investigations before any treatment is being considered or has been selected.

NOTE 2—"O" parameters are recommended in addition to "X" if the technology is being considered or has been selected.

3.1.1 *remedial treatment process, n— as used in this guide*, physical, chemical and biological technologies used to destroy, contain or remove contaminants of concern at contaminated sites.

3.1.2 *treatment process design data, n—as used in this guide*, physical and chemical data that are needed, in addition to data on contaminants of concern, characterization of the subsurface, and major factors affecting the surface and subsurface environment that are addressed in Guide D5730 to evaluate and design treatment processes for remediation of contaminated sites. Examples are cations and anions commonly present in water such as calcium, iron, carbonate/bicarbonate, Total Organic Carbon (TOC), pH, temperature, and sieve analysis. See Tables 1 and 2 for the complete list.

4. Significance and Use

4.1 This guide allows the decision maker to determine which remedial treatment processes are and are not applicable to remediate an area of soil, surface water or ground water that contains contaminants of concern.

4.2 This guide provides the data to make cost comparisons of the remedial treatment processes.

4.3 Analysis of treatment process design data can often be performed at the site with instruments and test kits.

4.4 Tables 1 and 2 are a guide to selecting and obtaining physical and chemical treatment process design data. Data marked with an "X" is needed to evaluate alternatives and select a remedial treatment process. Once the remedial process is selected the additional data that are needed to design the selected remedial treatment process are marked with an "O".

4.5 Tables 3 and 4 list laboratory and field methods for analyzing this data. More than one analytical method may be listed. The most suitable method must be chosen for each application.

4.6 This guide does not address sampling for contaminants and sampling locations. See EM 200-1-2 Technical Project Planning (TPP) under Engineering Manuals[6] for information on sampling contaminants of concern. It is recommended that the treatment process design sampling be coordinated with the sampling for chemicals of concern to minimize duplicate sampling and trips to the site.

4.7 This guide does not address physical and chemical properties related to contaminant transport. This is addressed in Guide D5730.

4.8 This guide does not address why the data is needed to evaluate each treatment technology. This information is addressed in the Federal Remediation Technologies Roundtable (FRTF) site at http://www.frtr.gov in the U.S. Army Corps of Engineers guidance documents at http://www.usace.army.mil/inet/usace-docs/ and the United Facilities Guide Specifications (UFGS) available at http://www.ccb.org/.

4.9 This guide does not address Quality Assurance/ Quality Control (QA/QC) or sampling design strategy. See U.S. Army Corps of Engineers Engineering Regulation ER 1110-1-263 and Engineering Manual EM 200-1-3[6] for information on QA/QC. This needs to be addressed in the Quality Assurance Project Plan (QAPP).

5. Keywords

5.1 analysis; environmental assessment; hazardous waste; remediation; sampling; solid waste

[6] United States Army Corps of Engineers, Technical Project Planning (TPP) Processes, Engineering Manual—EM 200-1-2, Publications of the Headquarters, available at http://www.usace.army.mil/inet/usace-docs/

TABLE 3 Water Analytical Methods[A]

Parameters	Laboratory Methods	Detection Range[B]	Field Test Methods Meter/Kit[C]	Detection Range[B]
pH[D,E]	EPA 150.1/150.2[F] ; SM 4500-H^{+}[G] ; Test Methods D1293	0 - 14 pH units	Meter[H]	
ORP[D,E,I]	SM 2580[G] ; Practice D1498		Meter	
Temperature[D,E]	EPA 170.1[F] ; SM 2550[G]	0 - 100°C		
Dissolved Oxygen (DO)[D,E]	EPA 360.1[F] ; SM 4500-O[G] 360.2	0 - 20 mg/L	Spectrophotometer (spec)/Meter[H]	1 - 10 mg/L
Conductivity[D,E]	EPA 120.1[F] ; SM 2510[G]	1 - 1,000 µS/cm	Meter	200 mS
Turbidity[D,E]	EPA 180.1[F]	0 - 40 NTU	Spec/Meter	0 - 4,400 NTU/0.1 - 100 NTU
Total dissolved solids	EPA 160.1[F]	10 - 20,000 mg/L	Meter	0 - 200 mg/L
Ammonia	EPA 350.1/350.2/350.3[F] ; SM 4500-NH_3[G]	0.01 - 2.0 mg/L	Spec/Kit[H]	0 - 2.5 mg/L
Kjeldahl (TKN)	EPA 351.1/351.2/351.3/ 351.4[F] ; SM 4500-N_{org}[G]	0.05 - 2.0 mg/L	Spec/Kit	1 - 150 mg/L
Anions				
F 0013B—electrode^{-}	EPA 340.1/340.2/340.3[F] ; SM 4500-F^{-}[G] 0300	0.1 - 1,000 mg/L	Spec/Kit	0 - 2 mg/L/0 - 2 mg/L
Cl^{-}	EPA 325.1/325.2/325.3[F] ; SM 4500 Cl^{-}[G] 0300	1 - 200 mg/L	Spec/Kit	0-20/5-400
NO_3^{-}	EPA 352.1[F] ; SM 4500-NO3-[G] ; Test Method D4327 0300	0.1 - 2 mg/L as N	Spec/Kit[H]	0 - 30/0 - 10 mg/L
NO_2^{-}	EPA 354.1[F] ; SM 4500-NO2-[G] 0300	0.01 - 1.0 mg/L as N	Spec/Kit[H]	0 - 0.3/0 - 1.0 mg/L
SO_4^{2-}	EPA 375.1/375.2/375.3/ 375.4[F] ; SM 4500-SO_4^{2-}[G] ; Test Method D4327 0300	3 - 400 mg/L	Spec/Kit[H]	0 - 70/50 - 200 mg/L
SO_3^{-}	SM 4500-SO3-B[G] . EPA 377.1[J]		Kit	
Alkalinity (HCO_3^{-}, CO_3^{2-})	EPA 310.1/310.2[F] ; SM 2320[G]	10 - 200 mg/L as $CaCO_3$	Kit[H]	10 - 4,000 mg/L
Phosphorus (Total)	EPA 365.4	0.01 - 20 mg/L	Spec/Kit[H]	0 - 3.5/0 - 5 mg/L
Cations				
Fe^{2+}[E]	USGS 1-1388-78[K]		Spec/Kit[H]	0 - 3/0 - 10 mg/L
Fe total (Fe^{2+} and Fe^{3+})	EPA 6010B/6020/7000A[J] 236.1/.2	5 - 40 µg/L	Spec/Kit[H]	0 - 3/0 - 10 mg/L
K^{+}	EPA 6010B/6020/7000A[J] ; 258.1	10 - 200 µg/L	Spec	0 - 7 mg/L
Na^{+}	EPA 6010B/6020/7000A[J] ; 273.1/2	1 - 200 µg/L	Meter	0 - sat
Ca^{2+}	EPA 6010B/6020/7000A[J] ; 215.1/2	50 - 200 µg/L	Kit[H]	1 - 350 mg/L
Mg^{2+}	EPA 6010B/6020/7000A[J] ; 242.1/2	1 - 100 µg/L	Kit	10 - 4,000 mg/L
Mn^{2+}	EPA 6010B/6020/7000A[J] 243.1/.2 SM 3120 B	0.1 - 1.0 µg/L	Spec/kit	0 - 0.7/ 0 - 3 mg/L
CH_4, C_2H_4, C_2H_6	EPA 8015B Modified[J] ; RSK-175[L]	10 - 100 µg/L		
Dissolved H_2	EPA NRMRL Ada OK method			
CO_2	SM 4500-CO_2[G]		Spec/Kit[H]	10 - 1000 mg/L/10 - 100 mg/L
Volatile fatty acid	SM 5560-Organic & Volatile Acids[G]			
H_2S (sulfide)	EPA 376.1/376.2[F] ; SM 4500-S^{2-}[G]	1 - 20 mg/L		
TOC	EPA 415.1/415.2[F] ; SM 5310[G]	50 µg/L - 10 mg/L		
BOD—5 day	EPA 405.1[F] ; SM 5210[G]			
Total Suspended Solids (TSS)	SM - 2540 D[G] ; 160.2			
COD	SM 5220[G] ; 410.1/2/3/4			
DOC	SM 5210 B			
Oil/grease	SM 5220[G] ; 431.1/2			
Bacteria Count	SM 9000[G]			

[A] This table was developed jointly by the U.S. Army Corps of Engineers, Hazardous, Toxic, and Radioactive Waste Center of Expertise and the U.S. Environmental Protection Agency Technical Support Project—Engineering Forum.
[B] Estimated sensitivity and detection ranges are method/kit specific. Consult the method or manufacturer's catalogs for details.
[C] Spectrometers and meters are instruments that can be used to analyze for many parameters. Kits cost much less, but usually analyze for only one parameter. There are many manufacturers of field test equipment.
[D] USEPA 600/4-84-017, *The Determination of Inorganic Anions in Water by Ion Chromatography*, March 1984.
[E] Parameters that should be analyzed in the field.
[F] USEPA 600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*, March 1983.
[G] American Public Health Association, *Standard Methods for the Examination of Water and Wastewater*, 20th Edition, January 1999.
[H] Use of test kits—Guide D5463.
[I] Use Nernst equation to check ORP field data.
[J] USEPA SW-846, *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods*, 3rd Edition, Updates I, IIA, IIB, III, IIIA, IVA, and IVB.
[K] A USGS method for ferrous iron analysis.
[L] *Analysis of Dissolved Methane, Ethane, and Ethylene in Ground Water by a Standard Gas Chromatohraphic Technique*, developed by USEPA National Risk Management Laboratory, Ada, OK.

TABLE 4 Soil, Sediment and Sludge Analytical Methods

Parameter	Analytical Method[A,B,C]	Field Test Kit Method
Reactivity	SW Chapter 7.3	
Atterberg Limits	Test Method D4943	
Specific Heat	Test Method D4611	
Soil Fusion Temperature	Test Method E953	
Moisture Content	Test Methods D2216, D6836	
Cation Exch. Cap. (CEC)	SW 9080/9081	Soil test kit[D]
Bulk Density	Test Method D4564	
Soil pH	Test Method D4972; SW 9045C	Soil test kit[D]
TOC (soil)	Walkley-Black; SW 9060 modified	
Field Capacity	Test Method D2325, Test Method D3152	
Halogen Content (Fluoride,Chloride)	SW 6010B / 6020A / 7000A[E]	
Fe	SW 7380 / 7381 / 6010B / 6020A[E,F]	
Mn	SW 7460/7461/6010B/6020A/7000A[E,F]	
Low Volatile Metals (Sb,As, Be,Cr, Na, K)	SW 6010B / 6020A / 7000A[E,F]	
Semi Volatile Metals (Pb, Cd, Hg)	SW 6010B / 6020A / 7000A[E,F]	Hg SW 7471A
Phosphorous (total)	SW 6010B[E]	Soil test kit[D]
Particle Size Analysis	Test Method D422-63	
Nitrate, Nitrite	SW 9210	Soil test kit[D]
Soil Permeability	Test Method D2434, Test Methods D5084[G]	
Humic Content	[H]	
Oil and Grease	SW 9071B Test Method D3921	
Alkalinity	SM 4500-CO2 B Test Methods D1067	
Kjeldahl Nitrogen	SM 4500-N, EPA 351.2 with acid dig.[I] Specification D3590	
Potassium	SW 6010B, 6020, 7000A[E]	Soil test kit[D]
Soil Oxygen	Field instrument with probe	Field instrument or detector tube with probe-tube and hand sample pump
Soil CO_2	Detector tubes	Field detector tubes with probe-tube and hand sampling pump
Thermal Conductivity	Test Method D5334	
Capillary Pressure	Test Methods D6836	
Na, Ca, Mg	SW 6010B/6020A	
Sulfate	SW 9035,9036,9038,9056	
Sulfur	Method 0016 in 40 CFR Part 60, Appendix A	
	Commonly done following TOC high temperature methods	

[A] *Standard Methods (SM) for the Examination of Water and Wastewater*, 18th edition, 1992.
[B] Except for soil oxygen and soil CO_2, soil samples can be analyzed in an off-site laboratory.
[C] Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846).
[D] Field test kits are often available that test for multiple parameters. There are several manufacturers of field soil test kits.
[E] Sample digestion required prior to analysis - see water parameters table.
[F] These metals can also be analyzed by Atomic Adsorption.
[G] Screening level.
[H] Estimate with Walkley-Black TOC and subtract other substances included in the TOC analysis.
[I] USEPA/600/4-79/020, Methods for Chemical Analysis of Water and Wastes, March 1983.

APPENDIX

(Nonmandatory Information)

X1. Example Application

X1.1 Knowing what data to collect relevant to treatment process design is an iterative process. Site history and other early information gathered at the site, and sampling for chemicals of concern and analysis from the contaminated site combined with professional judgment should provide ideas as to the contaminants of concern at the site. This information combined with the information in the references listed in 4.8 can be used to develop a list of remedial treatment processes that may be applicable to this contaminated site. Tables 1 and 2 can then be used to determine the treatment process design data that should be collected at the site to evaluate which of the applicable treatment process or processes are best for this site. These data is marked with an "X". More extensive data are needed to design the selected treatment process. These data are marked with an "O".

X1.2 An example use of this data is in evaluating activated carbon adsorption as a treatment process for removal of volatile organic contaminants (VOCs) from ground water. It is important to know the concentration of iron and calcium in the ground water, because these chemicals can foul and plug an activated carbon adsorption unit.

X1.3 The number of treatment process design data samples taken for analysis during the initial field sampling events should be kept to a minimum to save time and costs. Data that can be used as estimates for other parameters should be collected. For example, the humic content of the soil may be required for the final design of the selected process. Total Organic Carbon (TOC) soil analysis estimated by the Walkley-Black method is recommend in Tables 1 and 2 instead of