Information Paper 3.5
Measuring Suspended & Settlable Solids and Water Column Turbidity

Intent and Scope

The purpose of this package is to enhance the user's knowledge and ability to make decisions regarding measurements of turbidity, suspended solids, and settlable solids in various water bodies. Background information on the ecological significance of water column turbidity and the regulatory benchmarks that have been developed for it is provided in the Fact Sheet appended with this folder. This Information Paper (IP) supplies a "method menu" table with a description of available methods, their applications (purpose of use), and their approximate cost. This IP also provides information on the limitations and the extent of error associated with each method. The reader is then referred to the Standard Operation Procedures (SOPs) for each method (e.g., SOP-3.5.2: Measurement of Water Transparency Using a Transparency Tube.); these SOPs provide step-by-step instructions as well as method-specific Quality Assurance/Quality Control directions and data validation checklists

Selection, Principles and Applications of Methods

Table1 provides a "method menu" that includes the commonly used methods for measuring transparency, turbidity and suspended sediments in water samples. The menu is intended for use as a selection tool in response to the specific needs, level of operator skill, measurement quality objectives, and safety concerns of each individual project.

The principles and applications of measuring turbidity and suspended materials in various water bodies are discussed in three sections, below. The first section discusses methods of measuring water column turbidity through *transparency and light scattering evaluations.* The second section discusses evaluating the amount of material suspended in the water column by measuring the concentration of *suspended sediment.* Evaluating the potential for sedimentation of suspended material by assessing *settlable solids* is discussed in the third section.

Water Column Turbidity

Water appears less clear, or less transparent, if there are particles of solids (soil, algae, etc) suspended in it. The more particulates, the more turbid water can become. This attribute of water can be quantified in one of two ways:

- Transparency evaluations (Visual observation, Secchi disk, Transparency Tube, or Dual cylinder for transparency match)
- Light-scattering measurement (Nephelometric turbidity meters)

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Table 1. Method Menu: Performance, Cost, and Labor of Several Methods to Assess Water Column Turbidity and Suspended Sediments

Method Code	Method name (Parameter, unit)	Type	Kit cost	Labor (time)	Application	Limitation	Sources & Cumulative error
EYE	Visual Categories (Murkiness)	Transparency	None	30 sec	Turbidity watch, source ID		Not Applicable
SCD	Secchi disk (Secchi depth, cm)	Transparency	~$30	2 min	Status of Lakes and pools	Need to deploy from above Daylight only	Individual operator's vision, Lighting, surface reflection, depth measurements + or -- 30%
TRT	Transparency tube (Transparency, cm)	Transparency	$40	5 min	Turbidity in streams Source ID	Daylight only	Individual operator's vision Length measurement, deposition + or -- 30%
TUJ	Dual cylinder (Jackson turbidity, JTU)	Transparency match	$40	5 min	Turbidity in streams Source ID	Daylight only	Individual operator's vision, quality of standard, volume measurements + or -- 40%
TUN	Nephelometer (Turbidity, NTU)	Light-scattering	$500 and up	10 min cal 1 min measure	Turbidity in streams and lakes, Source ID		Error variable, depending on instrument
TUN	Automated Nephelometer (Turbidity, NTU)	Light-scattering	$1000 and up	Installation, calibration, download.	Use with data logger and/or trigger, storm events		Fouling of light absorbing surfaces
TSS	Filtration for Total Suspended Solids (TSS, mg/l)	Dry Weight per volume of sample aliquot	$2000 and up	20 min	Sediment loads assessments	Requires laboratory facility	Error variable, depending on operating procedures
SSC	Filtration for Suspended Sediment Concentration (SSC, mg/l)	Dry Weight per volume (by water weight) of whole sample	$2000 and up	20-60 min	Sediment loads assessments	Requires laboratory facility	Error variable, depending on operating procedures
MAJ	Mason Jar Method	Sinking	None	5 min (setup and read)	Crude separation by density		Individual operator's vision, uneven bottom, poor resolution + or – 100%
IC	Imhoff Cone Method	Sinking	~$30	5 min (setup and read)	Finer Separation by density	Requires cones	Lighting, surface identification, volume measurements + or – 30%

Visual categories can include: "Clear", "Cloudy" (bottom visible under 4" of water), and "murky" (bottom invisible)

Transparency evaluation is done by looking at the visibility of objects through a layer of water. The simplest assessment can be by visual categories, e.g., "Clear", "Cloudy" (bottom visible under 4" of water), and "Murky" (bottom invisible). One can also look at objects with clear patterns (e.g., Secchi disk) deployed in the water column, or in a long Transparency Tube. Either way, the column of water above the pattern is altered gradually and the depth of disappearance is recorded as "Secchi depth" or as "transparency", in centimeters (or meters in lake Tahoe!). Another way is comparing the visibility of a given pattern (black dot on white background) with a "turbidity" standard in a dual-cylinder test kit; the results are recorded in Jackson Turbidity Units (JTU) which reflect the amount of Standard solution added to match the sample's transparency. All the evaluations mentioned in this section can be performed in the field; the Transparency Tube and Dual Cylinder tests can also be performed in the lab, using a sample in a jar.

Nephelometric measurements utilize an instrument that shines light on the particles and measures the reflection or backscatter of the light by the particles. This value is expressed in Nephelometric Turbidity Units, or NTU (and is totally different from the light absorbance of the particles, which is measured by a photometer). Turbidity meters can be used both in the field and in the lab. Turbidity probes can also be installed in a stream or lake for continuous measurements, using automatic data loggers.

Suspended matter concentration

Evaluating the amount of material suspended in water by gravimetric method is done in a lab, because it requires time and bulky/heavy/non-mobile equipment. Collection of a representative sample (in terms of suspended solids) is a challenge, and the reader is urged to seek adequate guidance. Once the water sample is in a jar/bottle, suspended matter can be quantified by a method that involves collection of the suspended solids on a filter, drying, and weighing the loaded filter (and then subtracting the weight of the empty filter). This is called a "gravimetric" method because it deals with weight, and the results are normally reported as milligram (mg) suspended solids per one liter of sample (mg/l). Laboratories may use one of two variants:

- **Total Suspended Solids (TSS**) - a sample aliquot, rather then the whole bottle, is transferred to the filter for filtration, and the amount of sample used is measured directly as volume.
- **Suspended Sediment Concentration (SSC) -** the entire sample is filtered, on multiple filters if needed, rather than aliquots of it. The amount of sample used is measured by weighing the sample bottle (full and empty) and computing the volume from the water weight. This method is much more accurate because it circumvents error generated by sub-sampling and error associated with volume measurements (ASTM 1997, RSL 2000).

It must be noted that there is no direct relationship between the optical methods (transparency and Nephelometric turbidity) and the gravimetric methods, because each of the measured values is affected by different properties of the particles. However, the correlation between two parameters (e.g., TSS and NTU, or SSC and NTU) can be established for a particular drainage of uniform geological features and then NTU can be used as surrogate values to estimate TSS and possibly sediment loads.

Potential for Sedimentation

The potential for sedimentation of materials transported in water can be assessed either mechanically (by evaluating the amount of particles larger than a given size, as separated by sieving) or functionally (by evaluating the amount of particles that sink rapidly).

Separation by size (using sieves): An offshoot of the SSC method described above (ASTM 1997, RSL 2000) utilizes mechanical separation of sand and other particles by passing a sample through a sieve of certain pore size. The "size fraction" that remains on the sieve is then dried and weighed separately form the fraction of smaller particles (which had passed through the sieve). The results are usually reported as "percent sand" or as concentration, in mg/l, of each fraction. This method is somewhat indirect as it does not differentiate between slow-settling materials and fast-settling materials.
Separation by gravity: "Functional" separation, by gravity, is used to separate fast-settling materials from slow-settling materials. A water sample is placed in a container, such as a mason jar or an Imhoff cone (see Table 1) that allows measurement of how much material, in terms of volume, settles out of a water sample within a given period of time. The results of the evaluation are normally reported as milliliters (ml) of settleable solids per 1 liter of sample. Stormwater runoff "settleable solids" data, obtained by Imhoff cones, have been successfully used in the design of sedimentation basins and similar best management practices (BMPs).

Sources and Resources

This Information Paper has been created by the Clean Water Team implementing the Citizen Monitoring Program of the State Water Resources Control Board, in conjunction with a Technical Advisory Committee work group efforts. If you wish to reference this document, here is a good citation: State Water Resources Control Board (SWRCB), 2001. IP-3.5: Measuring Suspended & Settlable Solids and Water Column Turbidity, in: Compendium of Guidance for Citizen Monitors on Water Quality Monitoring and Assessment, Version 2.0. SWRCB, Sacramento, CA.

References used in the IP

American Society For Testing and Materials (ASTM) 1997. Standard Test Method for Determining Sediment Concentrations in Water Samples. Designation: D 3977 - 97. American Society For Testing and Materials, 100 Barr harbor Dr., West Conshohocken, PA 19428

Redwood Science Laboratory (RSL) 2000. Laboratory procedures for "total suspended solids" USDA Forest Service, Arcata, CA. (Note: the method is referred to as suspended sediment concentrations (SSC) by USGS and in the method menu table above).