PH

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pH

- Used to express the intensity of the acid or alkaline condition of a solution
- Measure H^+ activity in a solution
- Importance
  - Water treatment: e.g. coagulation, softening, and corrosion control
  - WW treatment: e.g. biological processes
  - Permit requirements
  - Acid or alkaline discharges can erode sewers or react with sewage to produce toxic hydrogen sulfide.

pH

- Neutrality: pH 7 at 25^{o}C
- Measurement:
- Using the color indicator (6 t 8 color indicators to determine pH)
- pH meter (glass electrode), pH buffer to calibrate before use, ^{o}C dependent
- $[H^{+}]$ never <0, but pH can be < 0 in highly acidic solutions

pH Measure Scale

The measurement scale is 0 – 14.

- Solutions with a pH of 7 are considered neutral.
- Solutions with a pH < 7 are considered acidic.
- Solutions with a pH > 7 are considered alkaline.

pH Testing

Standard Methods, Method 4500-H^+

Preservatives – None

Hold time – None. Analyze immediately upon collection. Biological activity can change the pH of a solution.

pH Procedure

Equipment

- pH meter
- pH electrode
- Temperature compensation probe

Chemicals

- pH buffers (typical buffer concentrations are 4, 7, and 10)

pH Procedure

Perform a two point calibration:

- Place electrode in low standard. Wait for meter to stabilize. Enter millivolts into meter memory
- Place electrode in high standard. Wait for meter to stabilize. Enter millivolts into meter memory.
- Verify slope is acceptable.
- Place electrode in sample. Wait for meter to stabilize. Record sample pH.

pH Procedure

pH – Helpful Hints

- Use color coded buffers.
- Samples and standards should be at the same temperature. Or use a temperature compensation probe.
- Make sure electrode contains sufficient electrolyte (usually saturated KCl.)
- Make sure electrolyte fill hole is open when taking measurements.
- Close electrolyte fill hole when electrode is not in use.
- Rinse electrode between samples.
- Store electrode in pH 7 buffer in between uses.

Problems

- What would be the pH of a solution containing a) 1.008 g of hydrogen ion per liter b) 0.1008 g of hydrogen ion per liter?
- A decrease in pH of one unit represents how much of an increase in hydrogen ion activity?

SUSPENDED SOLIDS

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CE404

ENVIRONMENTAL ANALYSIS

DEPARTMENT OF CIVIL ENGINEERING

SOLIDS

Solid Analysis Types

SS – settleable

TSS – total suspended solids

TS – total solids

TVS – total volatile solids

TVSS – total volatile suspended solids

WHY TEST FOR SOLIDS?

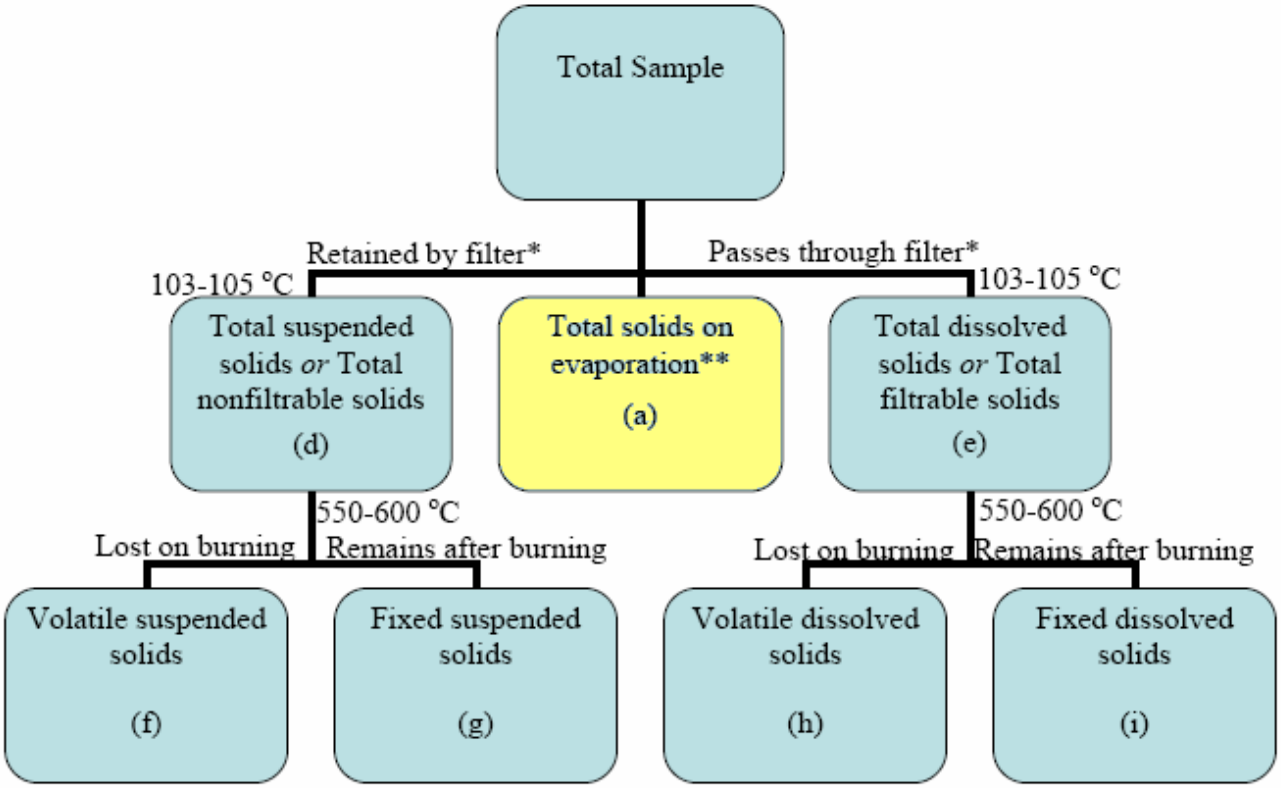
Permit requirements

Process control

- % TSS removal provides an indication of plant efficiency.
- %TVS & TVSS used in calculations for determining digester operation and F:M loading rates.
- % TS can be used to determine if enough water is removed from sludge during dewatering processes.

TS, TOTAL SOLIDS DEFINITION

- **Combined amounts of suspended and dissolved materials in a sample**
- **Not usually regulated**
- **Not significant for drinking water treatment**



* By convention, nominal filter pore size is 0.45 μm

** Total solids determined by evaporation (103-105°C) of whole sample, without filtration

(Total) Volatile solids = $f + h$

Fixed *or* Non-volatile total solids = $g + i$

*Courtesy Prof. Mark Benjamin, University of Washington, Department of Engineering CEE 483
Used with permission

TS, TOTAL SOLIDS PROCESS CONTROL LEVELS

Sample	Common Ranges
Raw sludge	6,000 mg/L to 90,000mg/L
Raw Sludge Plus Waste Activated Sludge	20,000 mg/L to 50,000 mg/L
Return Activated Sludge (RAS)	15,000 mg/L to 30,000 mg/L

TS, TOTAL SOLIDS

Equipment

Drying oven

Analytical balance

Desiccator

Ceramic dishes

Chemicals

Quality Control standard

SOLIDS TESTING

***Standard Methods*, Method 2540**

- 500 ml minimum sample
- Glass or Plastic
- Be consistent with sampling
- Run immediately

TS PROCEDURE

Weigh empty ceramic dish on analytical balance.

Shake or mix sample well.

Transfer sample to dish.

Weigh dish + sample.

Dry dish + sample in a 103 - 105 ^{0}C oven.

Cool dish in a desiccator,

Weigh dish + dry sample.

TOTAL SOLIDS

PROCEDURES - STEP BY STEP

- May use aluminum weighing dish
- Weigh dish in analytical balance to nearest .0001g (record as tare weight in grams)
- Measure out 50 ml of sludge sample
- Evaporate water in oven at 103° to 105°C for approximately 6 hours
- Cool dish and residue in desiccator
- Weight the dried residue and dish to nearest 0.0001g (Record in g)
- Repeat drying and weighing until results do not differ by more than 0.0004g

TOTAL SOLIDS

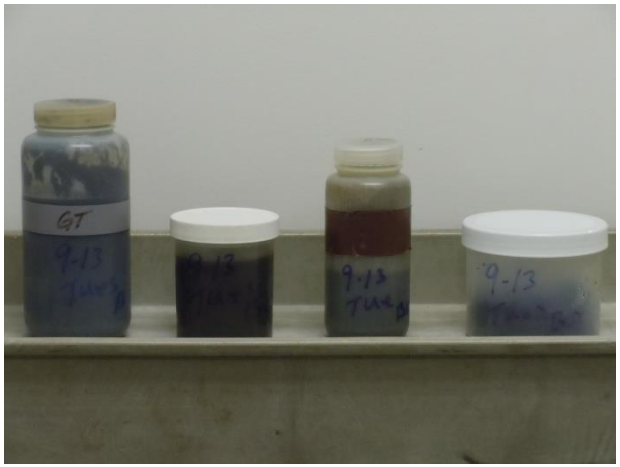
PROCEDURES

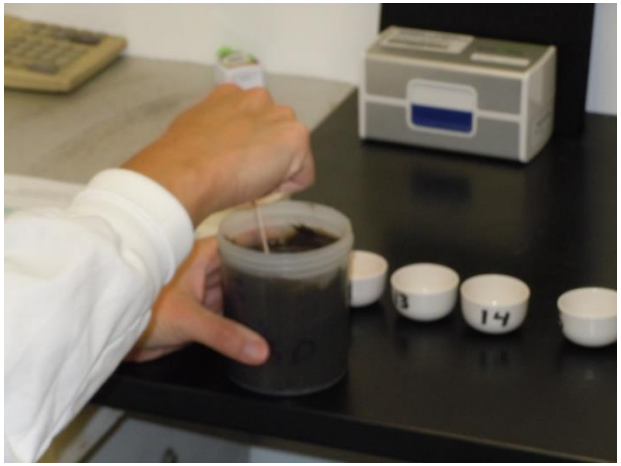
Calculation

- Total Solids, mg/L

$$= \frac{(\text{Dry weight of dish \& sample} - \text{Tare weight}) \times 1{,}000{,}000}{\text{Sample volume in ml}}$$

TS PROCEDURE





TOTAL SOLIDS

INTERPRETING READINGS

Sample	Common Ranges
Supernatant (effluent)	
Good Quality, has Suspended Solids	<10,000 mg/L
Poor Quality	>10,000 mg/L
Digested Sludge to Air Dry	30000 mg/L (thin) to <80000 mg/L solids

TVS, TOTAL SOLIDS

Equipment

Muffle furnace

Drying oven

Analytical balance

Desiccator

Ceramic dishes

Chemicals

Quality Control standard

TVS PROCEDURE

- **Place dry dish + sample in a 550^{0}C muffle furnace.**
- **Burn samples for 1 hour.**
- **Cool sample inside furnace until temperature is about 100^{0}C.**
- **Transfer samples to a desiccator and cool completely.**
- **Weigh cooled samples.**

Safety note: Muffle Furnace is very hot!

% TVS CALCULATION

% TVS =

$$\frac{\text{(g dish + dry sludge) - (g dish + ashed sludge)}}{\text{(g dish + dry sludge) - g dish}} \times 100\%$$

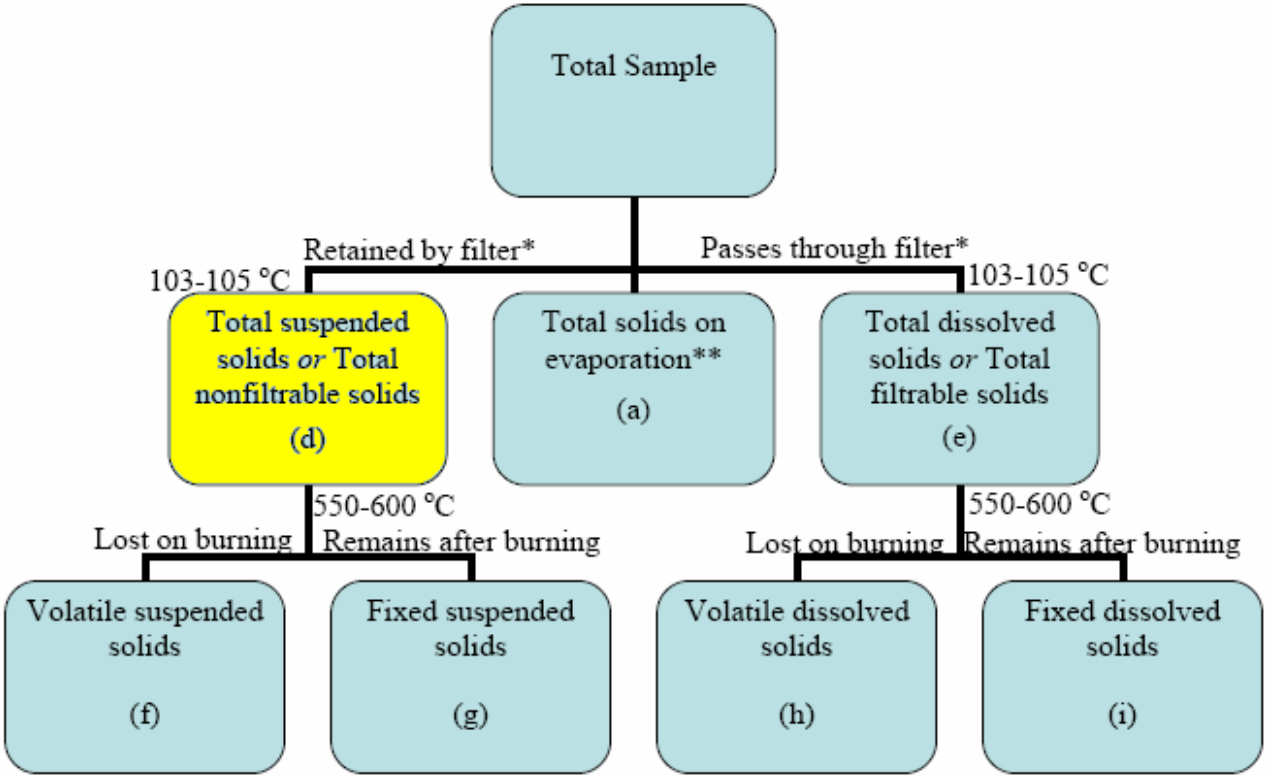
g = grams

TOTAL SUSPENDED SOLIDS

DEFINITION

- Also known as Total Non-Filterable Residue
- A combination of settleable solids and those solids that remain in suspension
- Measure of solids trapped in filter
- TDS=Not trapped in filter
- Reported in mg/L (concentration)

TOTAL SUSPENDED SOLIDS



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Fixed *or* Non-volatile total solids = $g + i$

TOTAL SUSPENDED SOLIDS REGULATORY AND PROCESS CONTROL LEVELS

NPDES permits regulate concentration and daily load

Not significant for drinking water treatment

Sample	Common Ranges
Influent	Weak 150 to 400+ Strong
Primary Effluent	Weak 60 to 150+ Strong
Secondary Effluent	Good 10 to 60+ Bad

Units in mg/L

TOTAL SUSPENDED SOLIDS
PROCESS CONTROL LEVELS

Sample	Common Ranges
Activated Sludge	Depends on Process
Mixed Liquor	1000 to <5000
RAS or WAS	2000 to <12,000
Digester Supernatant	3000 to <10,000

Note: If supernatant > 10K, run total solids test

Units in mg/L

TOTAL SUSPENDED SOLIDS

SAMPLING GUIDELINES

- **1000 ml minimum sample**
- **Glass or Plastic**
- **Preservatives – None. Store samples at 4^0C until time of analysis.**
- **Hold time – Preferably analyze samples as soon as possible after collection. Maximum hold time is 7 days.**

TSS,
TOTAL SUSPENDED SOLIDS

Equipment

Vacuum source

Drying oven

Analytical balance

Desiccator

Vacuum flasks

Gooches or filter supports

Pipets & graduated cylinders

Fiber glass filter paper

Chemicals

Quality Control standard

- Make from silica gel
- Purchase from vendor.

TSS PROCEDURE

Dry filter (and gooch, if using) in a 103 – 105^{0}C oven.

Weigh filter.

Shake sample well.

Pour or pipet sample through filter. Use vacuum.

Rinse filter and sample.

Dry filter (and gooch, if using) in oven.

Cool filter in a desiccator.

Weigh dried filter + sample.

TOTAL SUSPENDED SOLIDS

PROCEDURES – STEP BY STEP

Filter prep

- Place the filter disk rough side up in the filter holder apparatus (or Gooch crucible)
- Apply vacuum and wash the disk with 100 ml of DI water
- Release the vacuum from the filtering flask and remove the disk and place on watch glass if crucible not used
- Place in preheated oven at 103°C at one hour
- Use tongs to remove filter from furnace and place in a desiccator, cool to room temperature

TOTAL SUSPENDED SOLIDS

PROCEDURES – STEP BY STEP

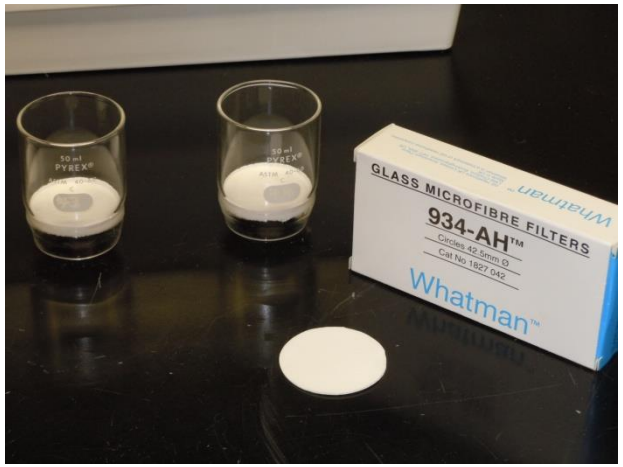
- Remove watch glass or crucible from the desiccator and place beside the analytical balance
- Remove the filter from the watch glass and weigh to the nearest 0.0001g, if using crucible, weigh the crucible
- Place the filter in the filtering flask assembly with wrinkled surface upward and wet with DI water
- Shake sample and pour measured amount of sample (100ml) in the assembly or the gooch crucible
- Apply vacuum and rinse the graduated cylinder, the assembly and filter with DI water
- Release vacuum and remove filter from filter assembly, or remove crucible from assembly

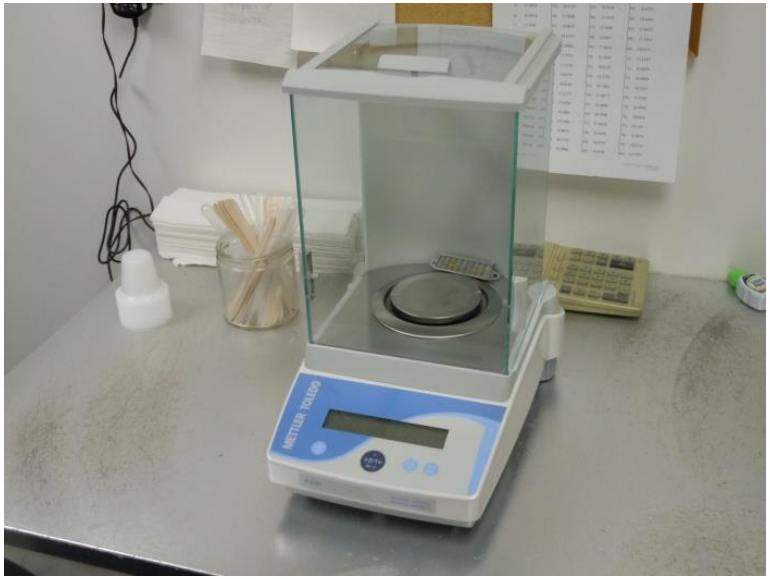
TOTAL SUSPENDED SOLIDS

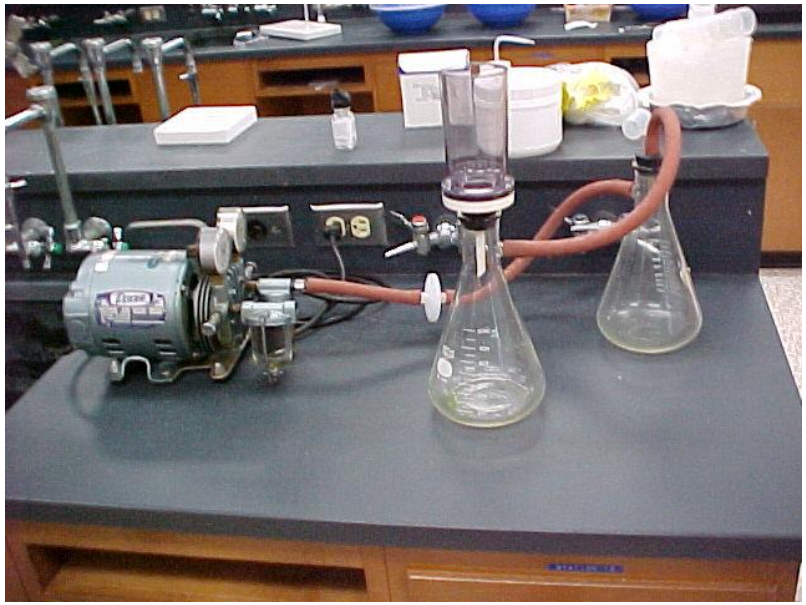
PROCEDURES – STEP BY STEP

- Place filter on watch glass and dry in oven at one hour for 103°C (or dry crucible plus filter)
- Remove from oven and cool in desiccator to room temperature
- Weigh filter or filter/crucible combination to nearest 0.0001 g
- Return filter to glass if the TVSS is to be determined, if not, discard. Same goes for disc in crucible
- Avoid losing any suspended matter on the filter
-

TSS PROCEDURE







TSS CALCULATION

mg/L TSS =

$$\frac{\text{(g filter/crucible + solids) - (g filter/crucible)}}{\text{mL sample}} \times \frac{1000\ \text{mL}}{\text{L}} \times \frac{1000\ \text{mg}}{\text{g}}$$

mg = milligrams

mL = milliliters

L = liters

g = grams

TOTAL SUSPENDED SOLIDS
PROCEDURES – CONSIDERATIONS

Don’t forget to record on bench sheet

Convert/record consistent units on sheet

TSS – HELPFUL HINTS

- **Shake sample well.**
- **Rinse graduate with DI water and add rinsing to filter.**
- **You can remove large, atypical material such as bugs.**
- **Verify oven temperature daily.**
- **Verify balance calibration daily.**
- **Make sure weights are stable before recording.**

TIPS FOR USING AN ANALYTICAL BALANCE

- **Locate balance away from drafts.**
- **Locate balance away from sunlight and/or other heat sources.**
- **Locate balance away from vibrations. (Use a marble slab if necessary.)**
- **Make sure balance is level. (Most balances have a sight level.)**
- **Make sure to tare balance (set to zero) before weighing.**
- **Clean up spills immediately.**

SOLIDS QUALITY CONTROL

Verify oven temperatures daily.

Run known quality control solutions on a routine basis.

Turbidity

CE404 Environmental Analysis

Department of Civil Engineering

Turbidity

- Suspended matters blocking the light passage through the water, e.g. colloidal particles, organics
- Concern: public water supplies
  - Aesthetics; filterability; disinfection
- Measurement:
  - Turbidimeter: to measure light scattered at right angles (different from colorimetric method)
  - Report as NTU
  - Use standards to calibrate turbidimeter first

Turbidity
Definition

- Defined as - *The cloudy appearance of water caused by the presence of suspended and colloidal matter (silt, organic matter, algae)*
- The optical property of the water based on the amount of light reflected by suspended particles

Turbidity *Definition*

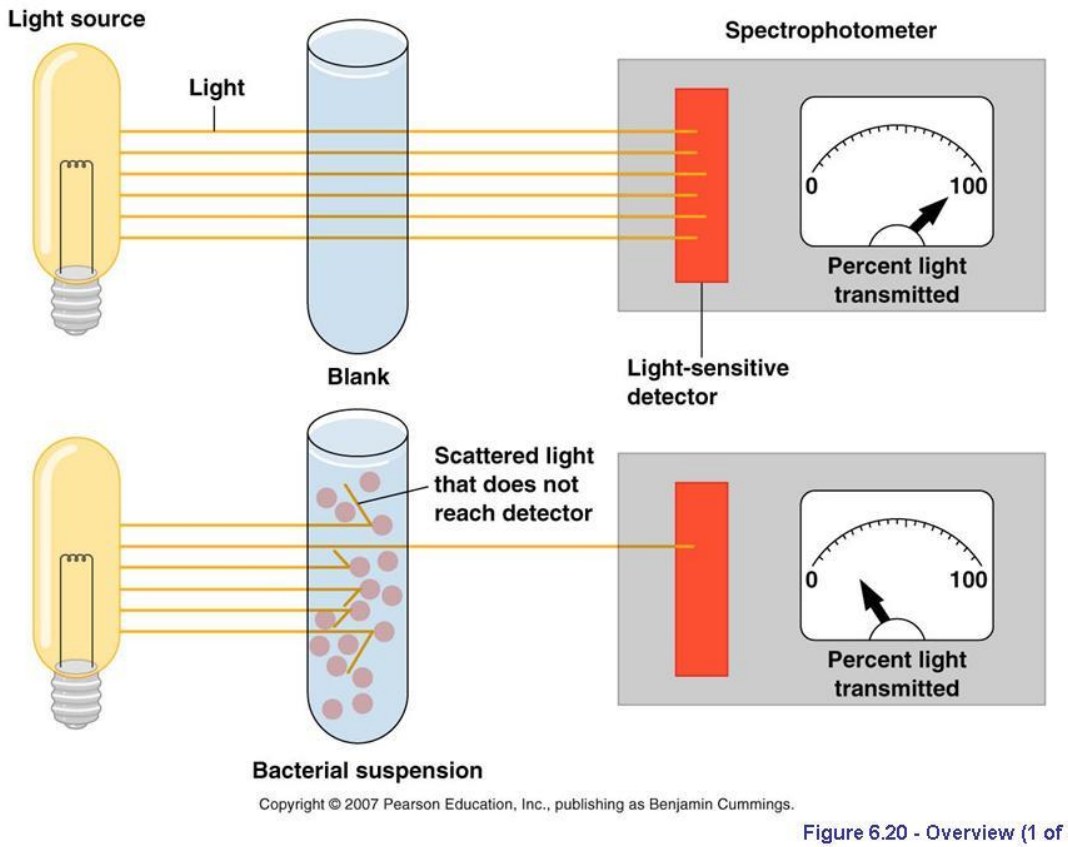
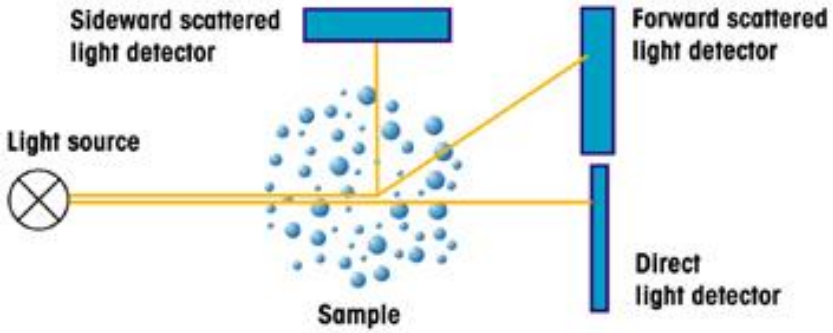


Figure 6.20 - Overview (1 of 3)



$$\text{Turbidity } 25^\circ \sim \frac{\text{Forward scattered light}}{\text{Direct light}}$$

$$\text{Turbidity } 90^\circ \sim \frac{90^\circ \text{ Scattered light}}{\text{Direct light}}$$

Source:
http://classes.midlandstech.edu/carterp/courses/bio225/chap06/lecture5.htm

Turbidity
Definition

- Water Treatment
  - Turbidity can interfere with disinfection and provide medium for bacterial growth
  - May indicate the presence of disease causing organisms
  - Directly affects amount of coagulant/coagulant aids added to feed/mix (Jar Testing)
- WasteWater
  - Can be useful for effluent monitoring

Turbidity
Definition

- Measured in Nephelometric Turbidity Units (NTU's)
- NTU - an empirical quantity based on the amount of light that is scattered by particles of a polymer reference standard called formazin which produces particles that scatter light in a reproducible manner

Turbidity
Definition

- Jackson Turbidity Units (JTU's)
- Visual method using the Jackson Candle (we won't be using this)
- NTU's are the accepted units

Turbidity
Regulatory and/or Process Control Levels

- Common Ranges in NTU's
  - Untreated Surface Water – 1 to 300
  - Filtered Water – 0.03 to 0.50
  - Well Water – 0.05 to 1.0+

Turbidity
Sampling Guidelines

- 1000 ml minimum sample
- Plastic or Glass
- Preserve by cooling at 4°C
- Max holding time 48 Hours (BMP to run sample ASAP but batching samples is acceptable)
- Thoroughly mix prior to measurement

Turbidity
Procedures

- Nephelometric procedure used
- Measures reflected light at 90 degrees of source beam
- Light strikes photocell which supplies voltage to meter

Turbidity
Procedures - Precautions

- Formazin standards made with hydrazine sulfate (CARC)
- Pre-made standards available from meter manufacturers
- Gel standards can be used for cal-check
- Use proper standard for appropriate calibration range

Turbidity
Procedures - Precautions

- Some meters require dilution when reading is expected to be above 40 NTU
- 1 part sample to X parts dilution water
- Calculate out to actual turbidity:

(Sample reading in NTU)(X+1)= Actual Turbidity

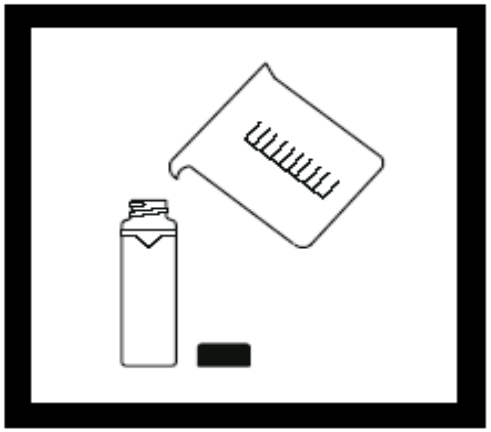
Turbidity
Procedures

- The following procedure is from the Hach Manual for the Model 2100P Turbidimeter:

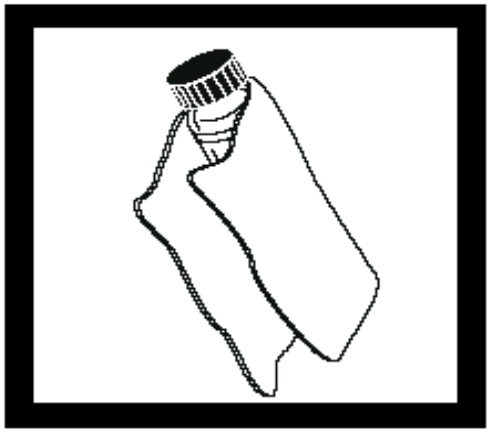
*Images and text courtesy Hach Company – used with permission

Turbidity
Procedures

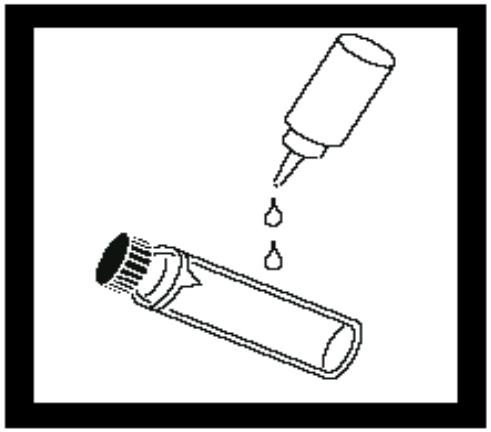
2.2.1 Turbidity Measurement Procedure



1. Collect a representative sample in a clean container. Fill a sample cell to the line (about 15 mL), taking care to handle the sample cell by the top. Cap the cell.

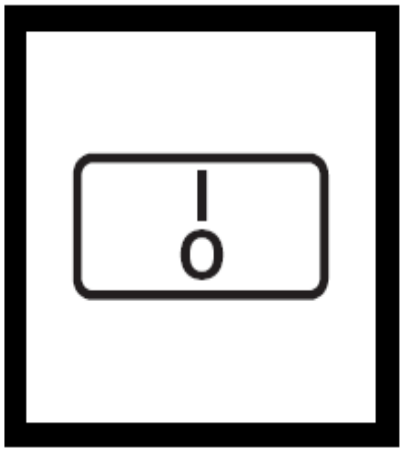


2. Wipe the cell with a soft, lint-free cloth to remove water spots and fingerprints.



3. Apply a thin film of silicone oil. Wipe with a soft cloth to obtain an even film over the entire surface.

Turbidity
Procedures

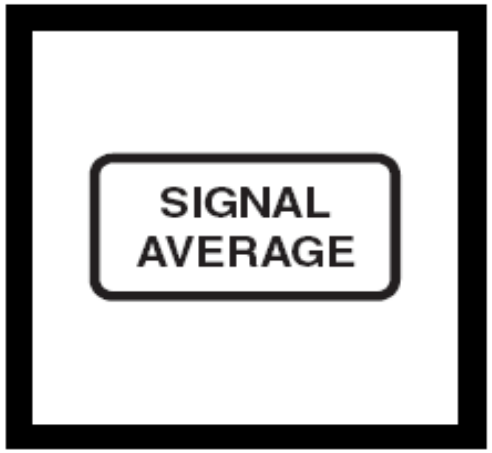


4. Press: **I/O**.

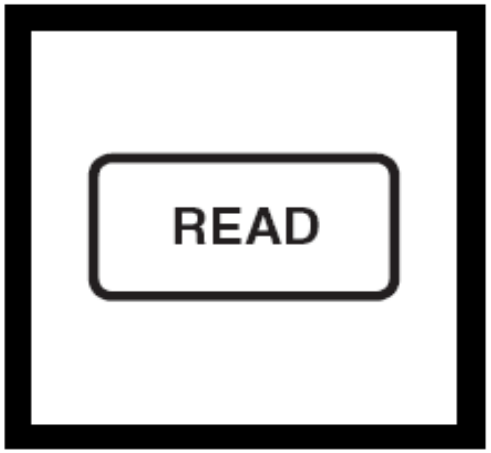
The instrument will turn on. Place the instrument on a flat, sturdy surface. Do not hold the instrument while making measurements.

5. Insert the sample cell in the instrument cell compartment so the diamond or orientation mark aligns with the raised orientation mark in front of the cell compartment.
Close the lid.

6. Select manual or automatic range selection by pressing the **RANGE** key. The display will show **AUTO RNG** when the instrument is in automatic range selection.



7. Select signal averaging mode by pressing the **SIGNAL AVERAGE** key. The display will show **SIG AVG** when the instrument is using signal averaging. Use signal average mode if the sample causes a noisy signal (display changes constantly).



8. Press: **READ**

The display will show **- - - - NTU**, then the turbidity in NTU. Record the turbidity after the lamp symbol turns off.

Turbidity
Procedures - Considerations

Always cap the sample cell to prevent spillage of sample into the instrument.

When taking a reading, place the instrument on a level, stationary surface. It should not be held in the hand during measurement.

Always close the sample compartment lid during measurement and storage.

Always use clean sample cells in good condition. Dirty, scratched, or damaged cells can cause inaccurate readings.

Turbidity
Procedures - Considerations

Do not leave a sample cell in the cell compartment for extended periods of time. This may compress the spring in the cell holder.

Remove sample cell and batteries from instrument if the instrument is stored for extended time period (more than a month).

Avoid operating in direct sunlight.

Turbidity
Procedures - Considerations

Make certain cold samples do not “fog” the sample cell.

Avoid settling of sample prior to measurement.

Keep sample compartment lid closed to prevent dust and dirt from entering.

Turbidity
Procedures – Recording Readings

Turbidity Reading	Record to Nearest
0.0 to 1.0	0.05
1 to 10	0.1
10 to 40	1

Turbidity
Procedures – Recording Readings

Turbidity Reading	Record to Nearest
40 to 100	5
100 to 1000	10
>1000	100

Turbidity
Interpreting Readings - Drinking Water

- High turbidity could indicate coagulation, sedimentation, filtration problems
- Check through the system for process control
- Ideal treatment plant finished water should be less than 0.1 NTU or less

Turbidity
Interpreting Readings - Wastewater

- Indicator of solids removal
- Not the same as suspended solids
- Suspended solids are primary wastewater process control guide

Turbidity
Plant and/or chemical feed adjustments

- More coagulant, different mix of chemicals, slower flow rate through clarifier, filter backwash

Turbidity

- Questions?