SOLIDS

Solids

* In env. eng., solids are measured in
  * Drinking water
  * Polluted water
  * Domestic and industrial wastewater
  * Sludges produced in treatment processes

Turbidity indicates Solids

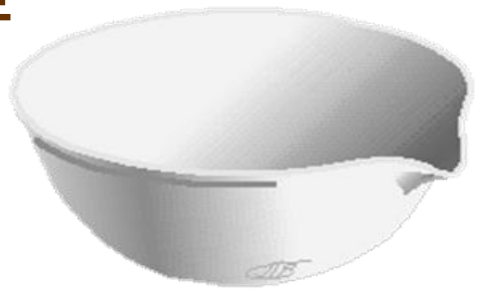
Turbidity is a visible indicator of the presence of “solids” in a water sample.

What are “solids”?

Total Solids

* Total solids of the sample is the matter left behind after drying a sample of water at 103-105°C
* The residue remaining upon evaporation
* All matter except water
* Metal salts, inorganic salts, organic material, insoluble salts, soluble salts, etc.

Evaporating Dish



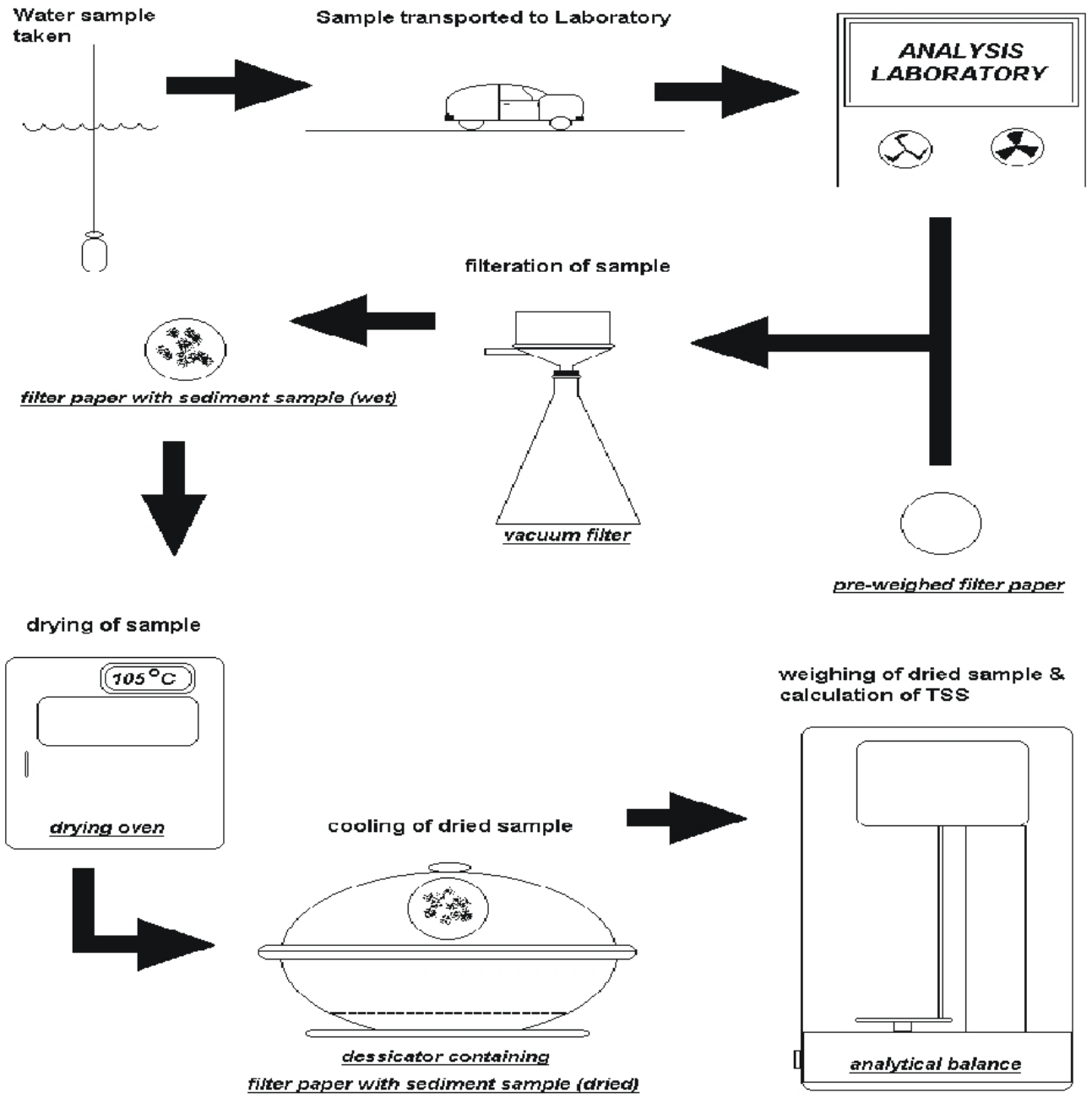
Total Solids

* There are two ways that solid materials may be classified
  * Suspended solids and dissolved solids
  * Volatile solids and fixed solids

Suspended vs dissolved

* Total suspended solids are the part of the sample that may be caught with a 0.45 µm filter
* Total dissolved solids are the part of the sample that will pass through the filter
* In drinking water:
  * Mostly→dissolved (inorganic salts, dissolved organics)
  * Range: 20-1000 mg/L
  * As TDS↑ →hardness ↑

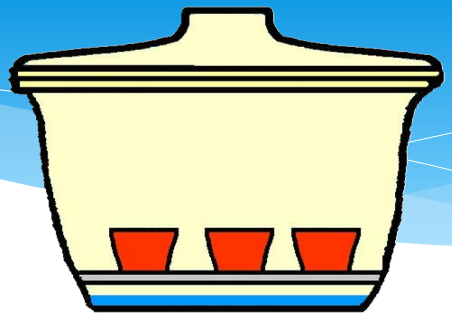
Total Suspended Solids



Desiccator

To Prevent Errors in Weighing of Crucibles by Providing a 0% Humidity Atmosphere
While the Crucibles Cool to Room Temperature.

Desiccator



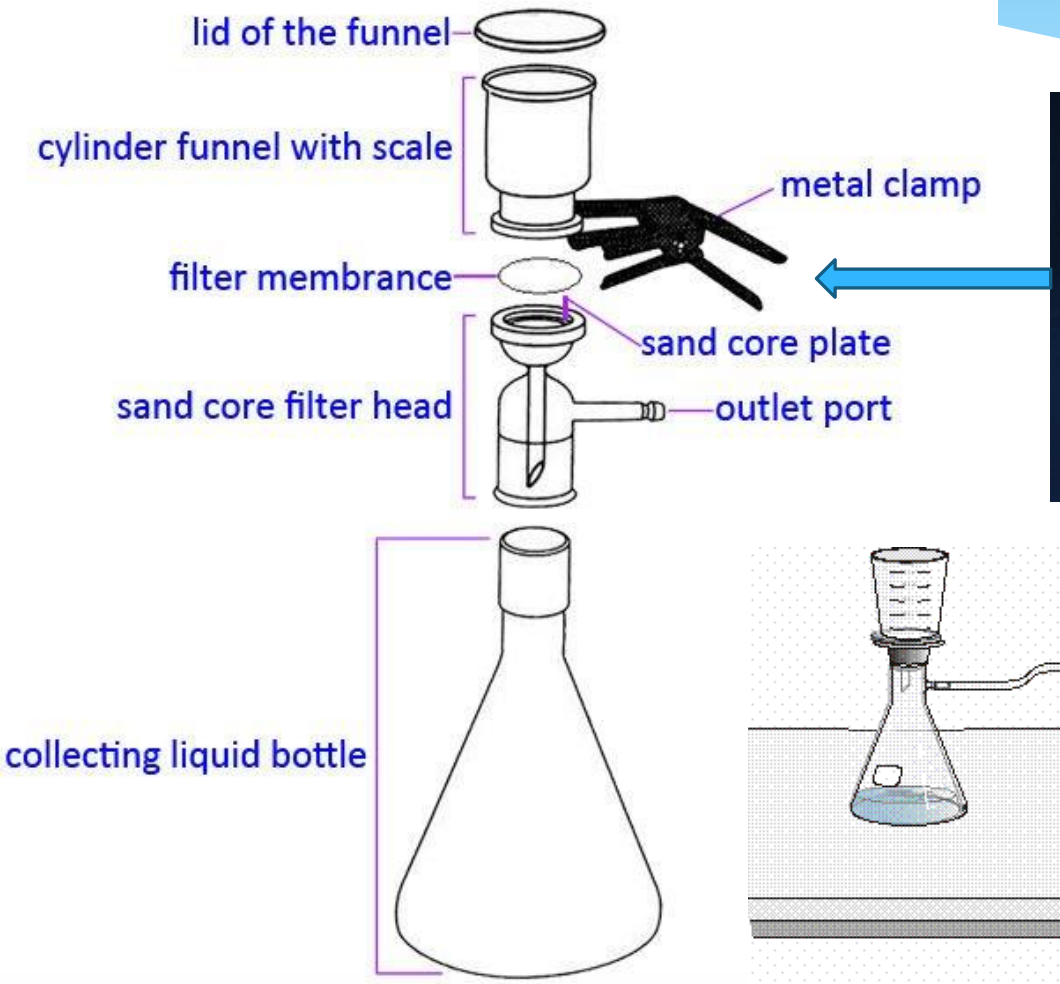
To Prevent Errors in Weighing of Crucibles by Providing a 0% Humidity Atmosphere
While the Crucibles Cool to Room Temperature.

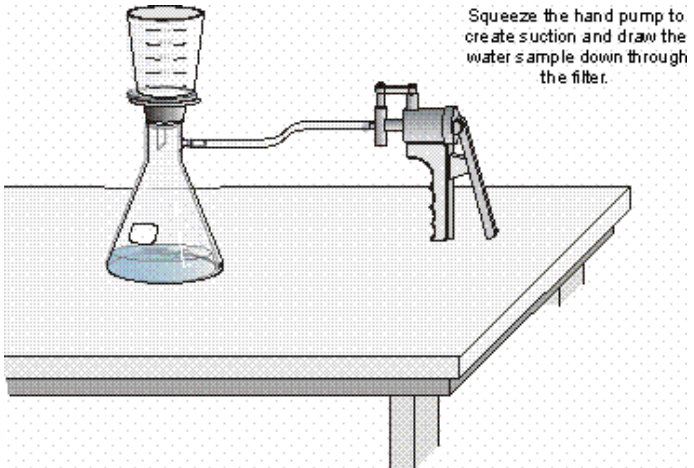
(Indicating Desiccant is Required)

Blue - Good

Pink – Must Be Replaced or Recharged

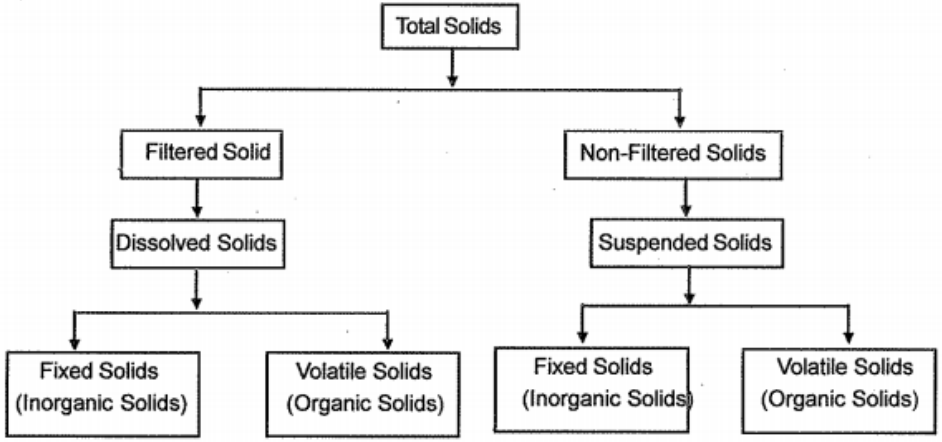
TSS measurement

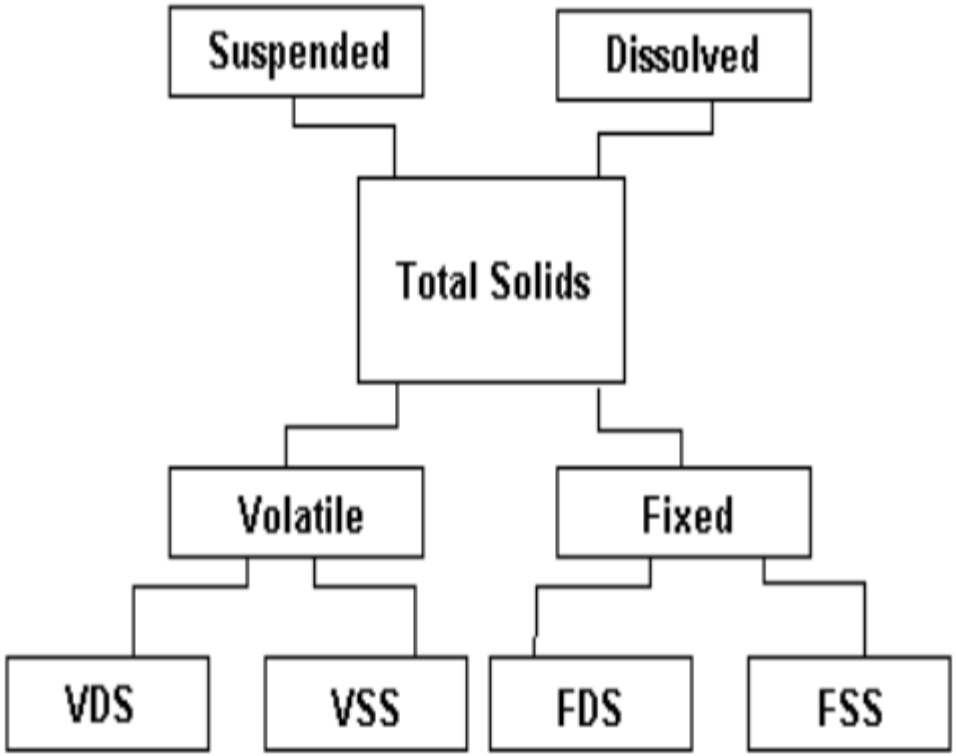


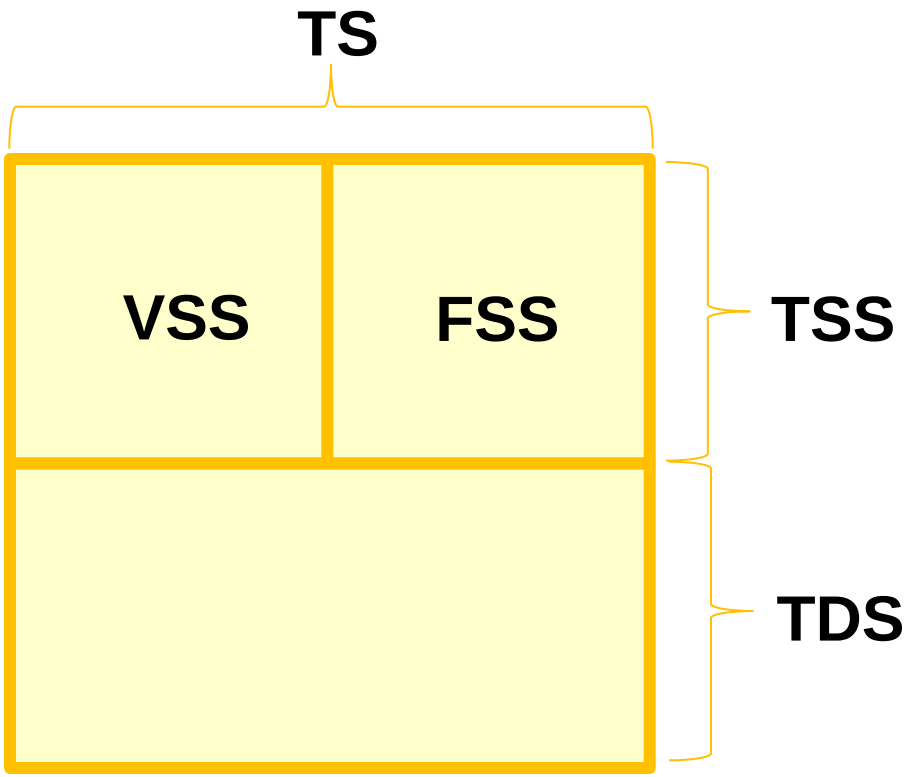


Volatile vs fixed

* Total volatile solids is the portion of the sample lost after the sample has been heated to 550°C. It is an approximation of the organic material present.
* Total fixed solids is the portion that still remains after heating. It is an approximation of the mineral matter present.


Total Solids
Filtered Solid
Non-Filtered Solids
Dissolved Solids
Suspended Solids
Fixed Solids (Inorganic Solids)
Volatile Solids (Organic Solids)
Fixed Solids (Inorganic Solids)
Volatile Solids (Organic Solids)


Suspended
Dissolved
Total Solids
Volatile
Fixed
VDS
VSS
FDS
FSS



Several of these fractions have significance in environmental engineering applications:

- TDS (saltiness) is important with respect to drinking water and irrigation;
- TSS (as turbidity) is used as a standard for safe drinking water consumption; and
- VSS (organic matter) provides a measure of a water to consume oxygen.

Calculation

$$\text{Total Suspended Solids, mg/L} = \frac{(B-A)(1000\frac{mg}{g})}{sample\ volume,L}$$

$$\text{Total Volatile Suspended Solids, mg/L} = \frac{(B-C)(1000\frac{mg}{g})}{sample\ volume,L}$$

$$\text{Total Fixed Suspended Solids, mg/L} = \frac{(C-A)(1000\frac{mg}{g})}{sample\ volume,L}$$

A= weight of the filter paper, g
B=weight of filter paper + residue dried at 105°C
C=wieght of filter paper + residue upon ignition at 550°C

Volatile and Fixed Solids

* Solids determination in organic wastes (domestic, industrial wastes and sludges) → Measure of organic matter.
* Combustion procedure is used in which organic matter is converted to gaseous CO_2 and water

Volatile and Fixed Solids

* Controlled temperature → prevent decomposition and volatilization of inorganic substances
* Ignition at 550°C → Lowest temperature at which organic matter oxidizes. Inorganic salts are stable

Volatile and Fixed Solids

* Organic matter → Loss in weight through high temperature oxidation and volatilization
* Ignition at 550°C → Pyrolysis of carbohydrates and other organics

$$C_x(H_2O)_y \xrightarrow{\Delta} xC + yH_2O\uparrow$$

$$C + O_2 \xrightarrow{\Delta} CO_2$$

Volatile and Fixed Solids

* At 550°C decompsition of inorganic salts is minimized
* Ammonium compounds are volatilized
* Most other inorganic salts stay stable,
  exception: $MgCO_3$

$$MgCO_3 \xrightarrow[350^{o}C]{} MgO + CO_2\uparrow$$

Volatile and Fixed Solids

* Dissolved inorganic salts are not a consideration → removed during filtration
* Analysis is conducted in muffle furnace → Accurate control of temperature
  * $CaCO_3$ decomposes @ 825°C
  * $CaCO_3$ is a major component of inorganic salts

Volatile Solids

* If wastewater (especially industrial) contains volatile solids in the organic portion (short chain fatty acids, ketones, aldehydes, HC) → lost during evaporation. Solids measurement does not give idea about organic content.

Settleable Solids

* Solids in suspension that will settle because of the influence of gravity
* Only the coarser suspended solids with SG>water will settle
* Determined using Imhoff cone
* 1 h of settling tank
* Unit: mL / L
* Important
  * to determine the need for sedimentation
  * Physical behaviour of waste streams entering natural water bodies

Environmental Significance of Solids

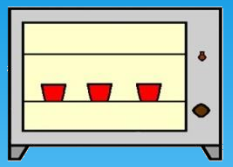
* For drinking water use, dissolved solids < 500 mg/L is most desirable
* If higher →
  * Laxative or reverse effects on people whose bodies are not used to the higher levels
  * Imparts taste to water
  * Water stain glassware
  * Adverse impacts on irrigated crops, plants and grasses
* Standard recommended max. value 1000 mg/L

Volatile Suspended Solids

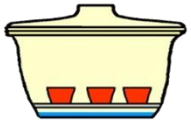
Pour measured volume of sample

Filter with vacuum.

Wash graduate, and filter with distilled water.

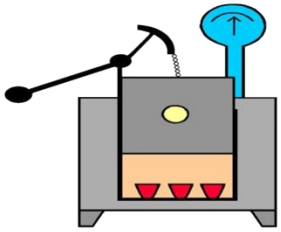


Dry filter paper plus solids for one hour at 103 ° C.

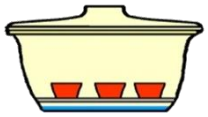


Cool in desiccator to room temperature

Weigh filter paper plus suspended solids.



Ignite in muffle furnace at 550 deg. C for 15 minutes

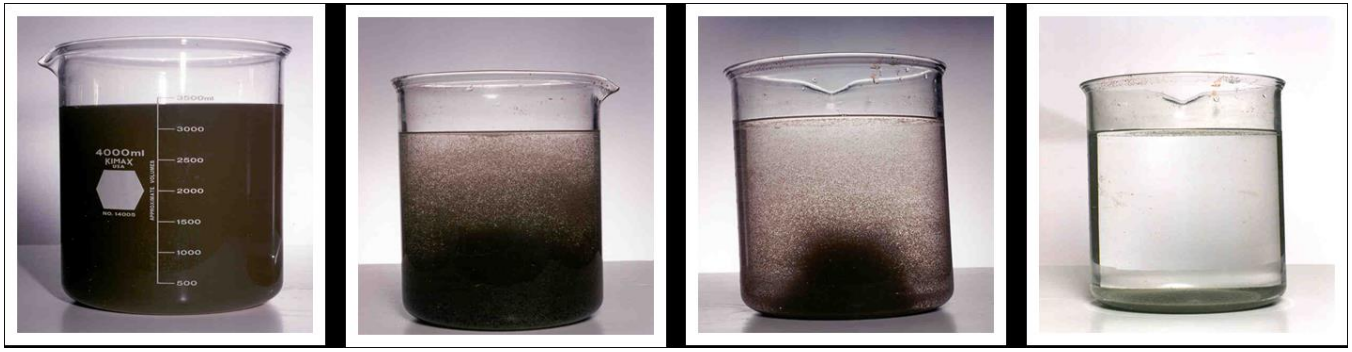


Cool in desiccator to room temperature

Weigh filter paper plus ash.

Environmental Significance of Solids

* Importance of suspended solids content
  * Regulated for wastewater effluent
  * SS may float and form scum layers
  * SS may sink and cause sediment buildup



Solids in water supplies

* Dissolved solids are of major concern→specific conductance
* SS are seldom made, instead turbidity analysis can be done
* Volatile solids (organic content)→not considered→TOC analysis can be done instead

Solids in polluted waters/ domestic wastewaters

* Settleable solids
* Dissolved solids may be an important part, however other methods like COD and BOD can be used to assess organic matter more exactly
* Suspended solids is a parameter in ww to determine the strength of ww and the efficiency of treatment units
* In stream-pollution-control work, aa SS are considered to be settleable solids, as time is not a limiting factor.

Solids in industrial wastewaters

* Include a wide variety of materials → all solids tests may be important
* Settleable solids test→important to determine if primary sedimentation tank is req'ed.

Applications of Solids Analysis in Environmental Engineering

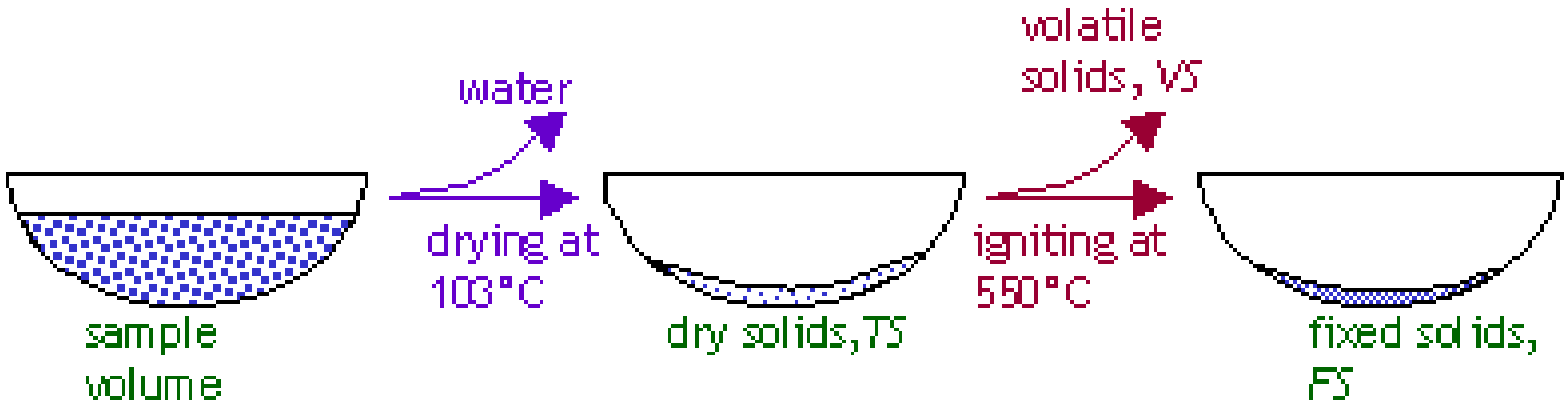
Application	TS	VS	TDS	TSS	VSS
Drinking Water			X		
Natural Waters			X	X	
Municipal Wastewater				X	X
Industrial Wastewater	X	X	X	X	X
Sludge	X	X			

Some Typical Solids Concentrations

Source		Concentration (mg/L)		
		Low	Avg	High
NATURAL WATERS				
Fresh	TDS	20	120	1,000
Brines	TDS	5,000		300,000
DOMESTIC WASTEWATER				
Raw	TDS	350	600	900
	VDS	165	285	600
	TSS	100	200	350
	VSS	75	135	215
Secondary Effluent	TSS	10	30	60
Activated Sludge Mixed Liquor (conventional)	TSS	1,500		3,000
Activated Sludge Mixed Liquor (extended aeration)	TSS	3,000		6,000
Primary Sludge	TSS	20,000		70,000
Secondary Sludge	TSS	5,000		12,000
STORM WATER	TSS	5	300	3,000

Example

* Given the following data:
* Weight of a dish = 48.6212 g.
* 100 mL of sample is placed in a dish and evaporated.
* Weight of the dish and dry solids = 48.6432 g.
* The dish is then placed in a 550°C furnace, then cooled. Weight = 48.6300 g.
* Find the total, fixed, and volatile solids (expressed as mg/L).


water
volatile
solids, VS
drying at
103°C
igniting at
550°C
sample
volume
dry solids, TS
fixed solids,
FS

$$\text{Total Solids} = \frac{(\text{dish} + \text{dry solids}) - (\text{dish})}{\text{sample volume}}$$

$$= \frac{48.6432 - 48.6212}{100}$$

$$= (220)10^{-6}\ \text{g/mL}$$

$$= (220)10^{-3}\ \text{mg/mL}$$

$$= 220\ \text{mg/L}$$

$$\text{Fixed Solids} = \frac{(\text{dish} + \text{unburned solids}) - (\text{dish})}{\text{sample volume}}$$

$$= \frac{48.6300 - 48.6212}{100}$$

$$= 88\ \text{mg/L}$$

$$\text{Volatile Solids} = \text{Total Solids} - \text{Total Fixed Solids}$$

$$= 220 - 88 = 132\ \text{mg/L}$$

Conductivity

What is conductivity?

- Conductivity is an indication of the quantity of ions contained in a solution
- to determine if the sample can carry an electrical current via the movement of ions. This ability depends on the presence of ions; on their total concentration, mobility, and valence; and on the temperature of measurement.

Why do we care?

- Dissolved ions/substances/electrolytes in water
- Determine the presence of salt water intrusion
- Used for WQ in pipelines, channels, flowing streams, and lakes

Conductivity

What are the units and conversions?

- Conductivity is customarily reported in micromhos per centimeter (µmho/cm). The electrical measurement of conductivity is the inverse (reciprocal) of ohms (1/ohms) or mhos.

- In the International System of Units (SI) the reciprocal of the ohm is the siemens (S) and conductivity is reported as millisiemens per meter (mS/m)

- 1/ohm = 1 mho = 1 Siemens
- 1000 micromhos/cm = 1000microSiemens/cm(µS/cm)

Conductivity

What are typical values in nature?

	Range
• Pure Water	0.05 µS/cm
• Demineralized Water	0.1 to 1.0 µS/cm
• Distilled water	1 to 10 µS/cm
• Tap Water	100 to 1000 µS/cm
• Potable water	50 to 1500 µmhos/cm.
• Industrial wastes	1000 to 10,000 µS/cm
• Seawater	30,000 to 50,000 µS/cm
• 5% Sodium Chloride Solution	70,000 µS/cm
• 10% Sulfuric Acid Solution	140,000µS/cm

Conductivity and Total Dissolved Solids

- Estimate total dissolved solids (mg/L) in a sample by multiplying conductivity (in micromhos per centimeter) by an empirical factor

- This factor may vary from 0.55 to 0.9, depending on the soluble components of the water and on the temperature of measurement.

- Linear in dilute systems

TDS meter