Environmental Chemistry

Solids

Lecture 9

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Solids: Physical characteristics

- Solids: The most important of physical characteristics
- Others: particle size distribution, turbidity, color, transmittance, conductivity, density, specific gravity, specific weight etc.
- Water, wastewater and air samples contain a variety of solid materials
- For WW samples, coarse materials will be removed before solids be analyzed

Definitions for solids in wastewater …

Test	Description
Total solids (TS)	Residue remaining after WW sample has been evaporated and dried at 103 to 105^{o}C
Total volatile solids (TVS)	Solids that volatized and burned off when TS are ignited (500 ± 50^{o}C)
Total fixed solids (TFS)	Residue that remains after TS are ignited (500 ± 50^{o}C)
Total suspended solids (TSS)	Portion of TS retained on filter with specified pore size, measured after being dried at 105oC. Most commonly is Whatman glass fiber filter (pore size 1.58 ∝m)

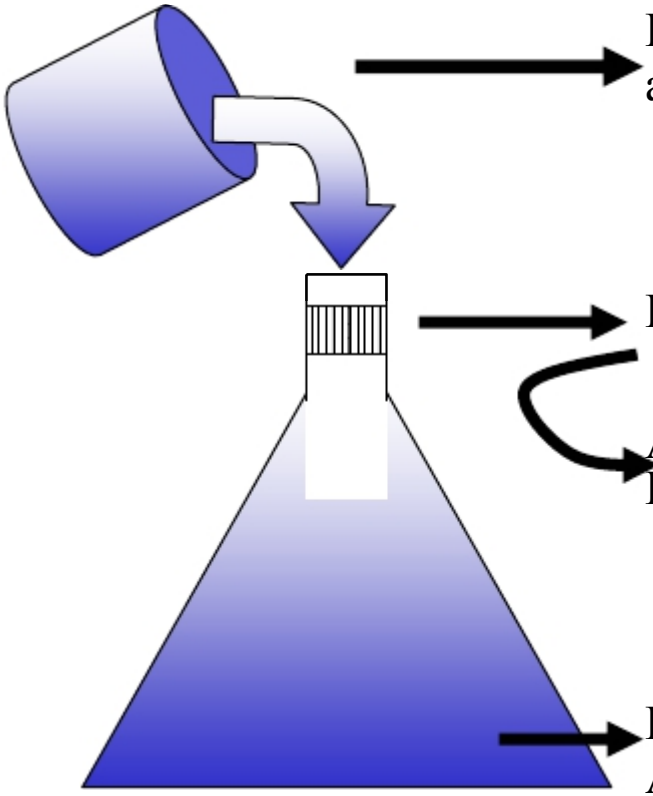
… Definitions for solids in wastewater …

Test	Description
Volatile suspended solids (VSS)	Solids that can volatized and burned off when TSS are ignited at 500 ± 50$_o$C
Fixed suspended solids (FSS)	Residue that remains after TSS are ignited (500 ± 50$_o$C)
Total dissolved solids (TDS)	Solids that pass through the filter, and are then evaporated and dried at specific temperature. Consists of colloidal (0.001 to 1 ∝m) and dissolved solids.

… Definitions for solids in wastewater …

Test	Description
Total volatile dissolved solids (VDS)	Solids that volatized and burned off when TDS are ignited at 500 ± 50$_o$C
Fixed dissolved solids (FDS)	Residue that remains after TDS are ignited (500 ± 50$_o$C)
Settleable solids	Suspended solids, expressed as mL/L that will settle out of suspension within a specified period of time

… Definitions for solids in wastewater …



Place sample in crucible and dry at 103^{o}C → Wt gain of crucible/mL = TS

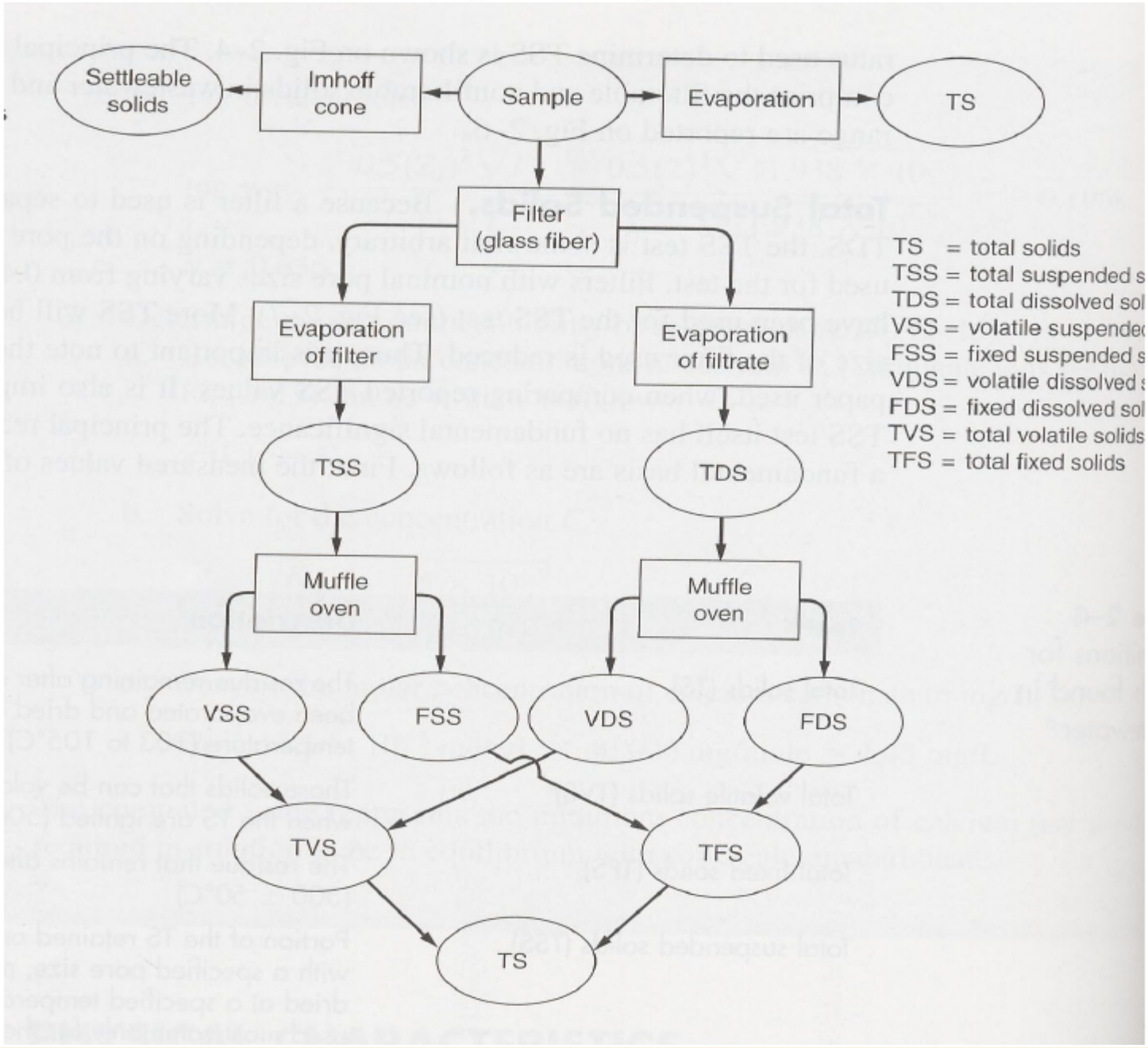
Dry filter at 103^{o}C → Wt gain of filter/mL = TSS

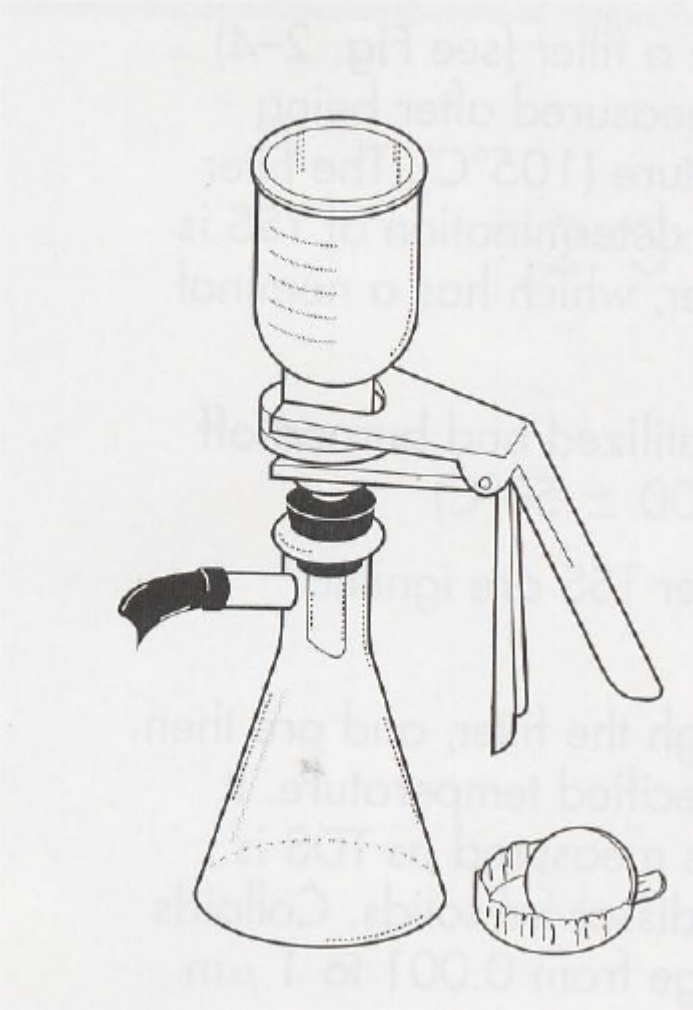
After drying, place filter in Furnace at 550^{o}C → Wt loss of filter/mL = VSS

Place filtrate in crucible And dry at 103^{o}C → Wt gain of crucible/mL = TDS

Matrix showing interactions between various types of solids in aqueous samples

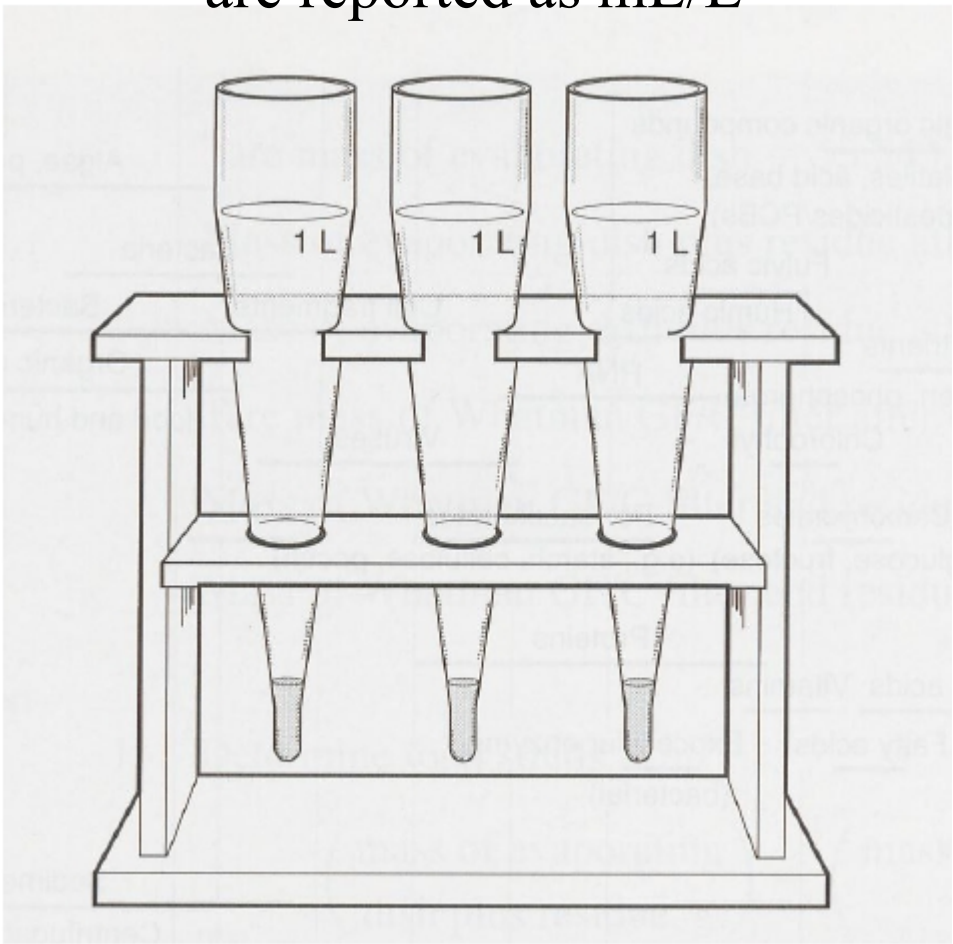
TS	=	TDS	+	TSS
		=		=
TVS	=	VDS	+	VSS
		+		+
TFS	=	FDS	+	FSS


Settleable solids
Imhoff cone
Sample
Evaporation
TS
Filter (glass fiber)
Evaporation of filter
Evaporation of filtrate
TSS
TDS
Muffle oven
Muffle oven
VSS
FSS
VDS
FDS
TVS
TFS
TS
TS = total solids
TSS = total suspended s
TDS = total dissolved sol
VSS = volatile suspende
FSS = fixed suspended s
VDS = volatile dissolved
FDS = fixed dissolved sol
TVS = total volatile solids
TFS = total fixed solids



Apparatus used for the determination of TSS. After wastewater sample has been filtered, the pre-weighted filter paper is placed in an aluminum dish for drying before weighing.

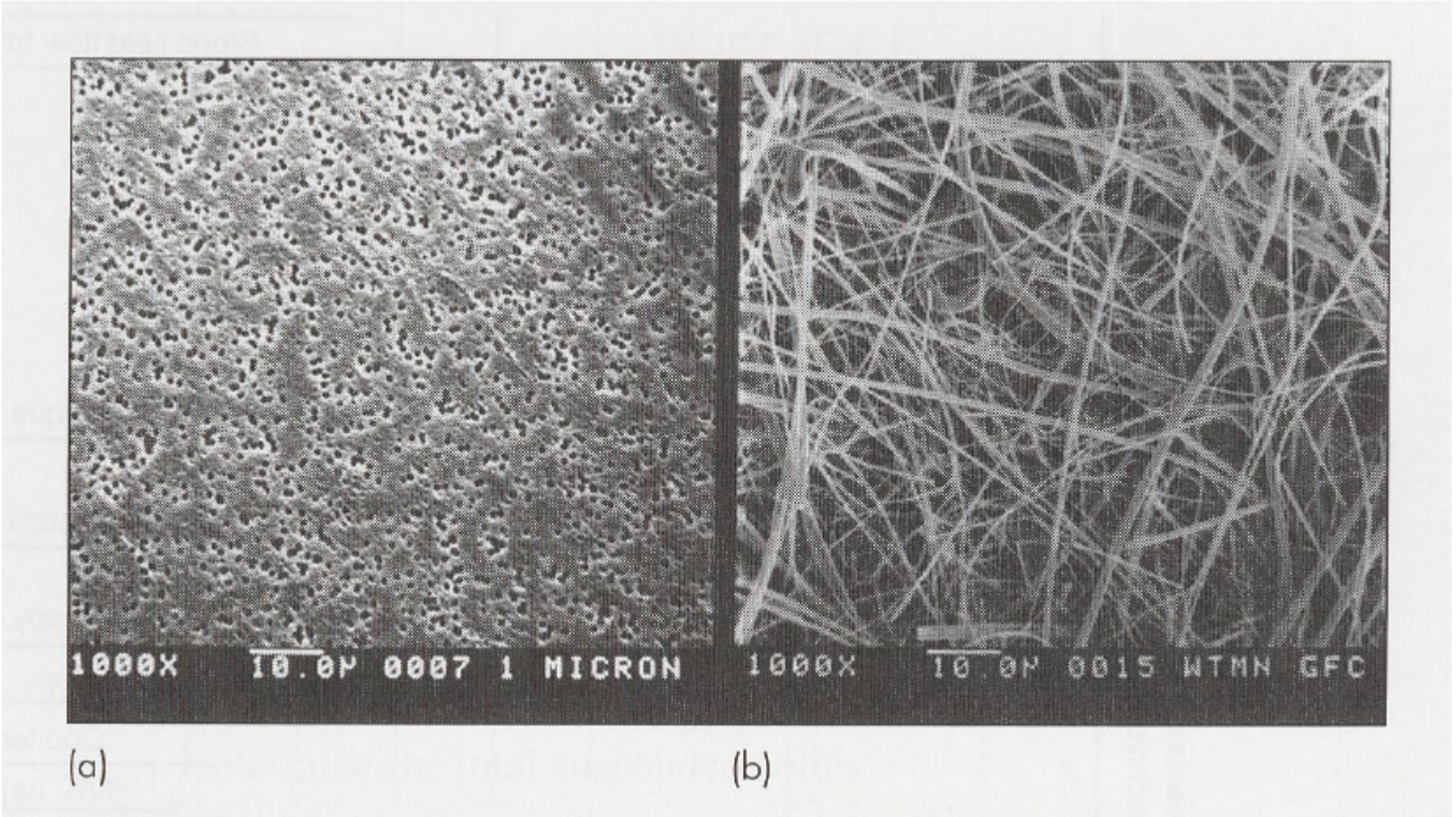
Imhoff cone used to determine settleable solids in wastewater. Solids that accumulate in the bottom of the cone after 60 min are reported as mL/L



Micrographs of two laboratory filters used for the measurement of suspended solids in wastewater.

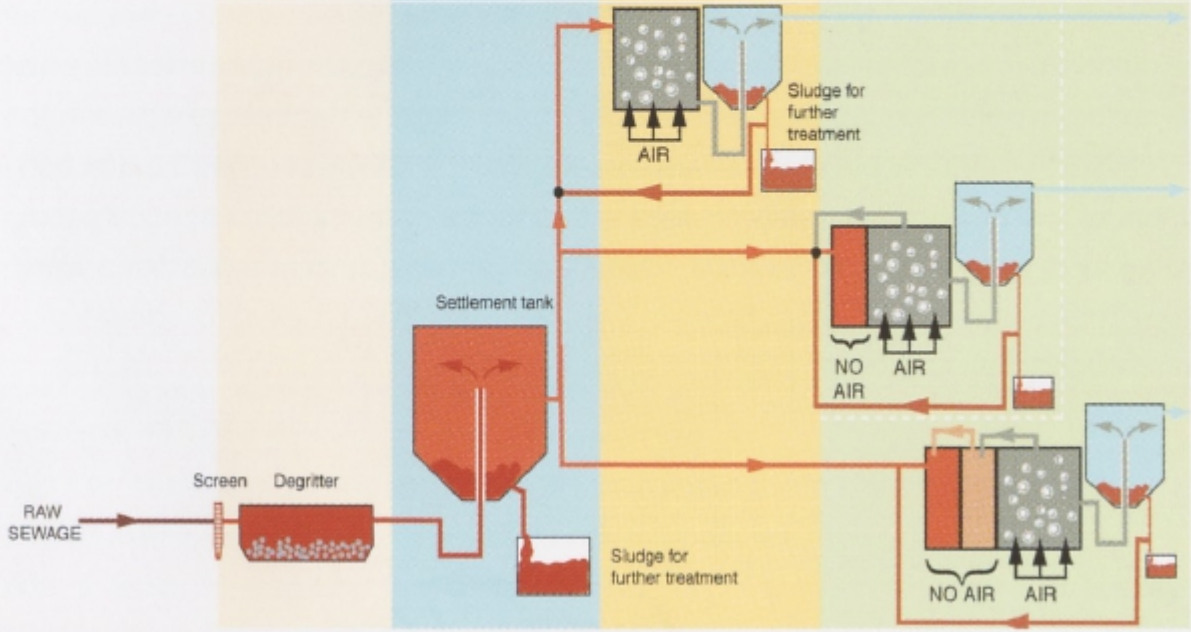
(a) Polycarbonate membrane filter with a nominal pore size of 1.0 μm.

(b) Glass fiber filter with a nominal pore size of 1.2μm



Principles of end-of-pipe pollution control

Amount of main pollutants removed	PRELIMINARY	PRIMARY	SECONDARY	TERTIARY	
Organic Material (BOD)	0%	30%	85%	85%	85%
Suspended Solids	5%	40%	96%	96%	96%
Nitrogen	0%	2%	5%	97%	97%
Phosphorus	0%	0%	2%	5%	95%
			Basic BOD removal only	BOD & Nitrogen Removal	BOD, Nitrogen & Phosphorus Removal



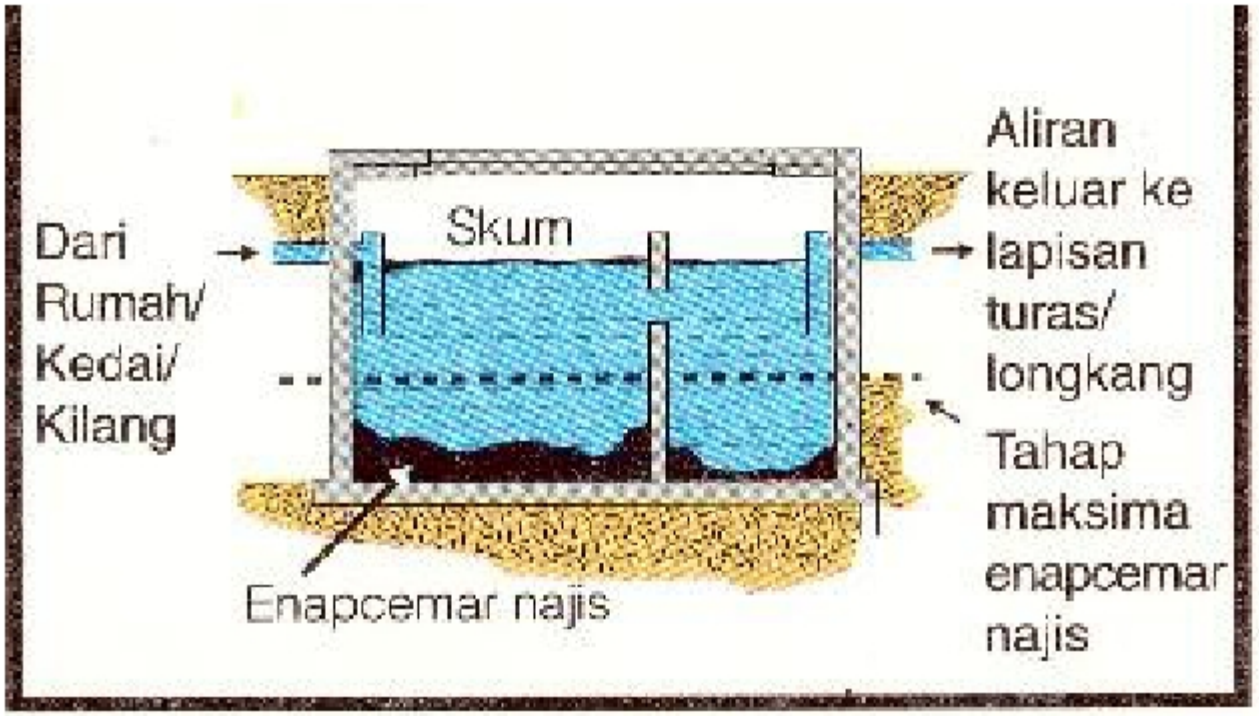
The main pollutants in sewage - solids, oxygen demand (BOD), nitrogen and phosphorus - are removed by successive treatment stages.

Conventional wastewater pollution control

What is the components of the colored materials?

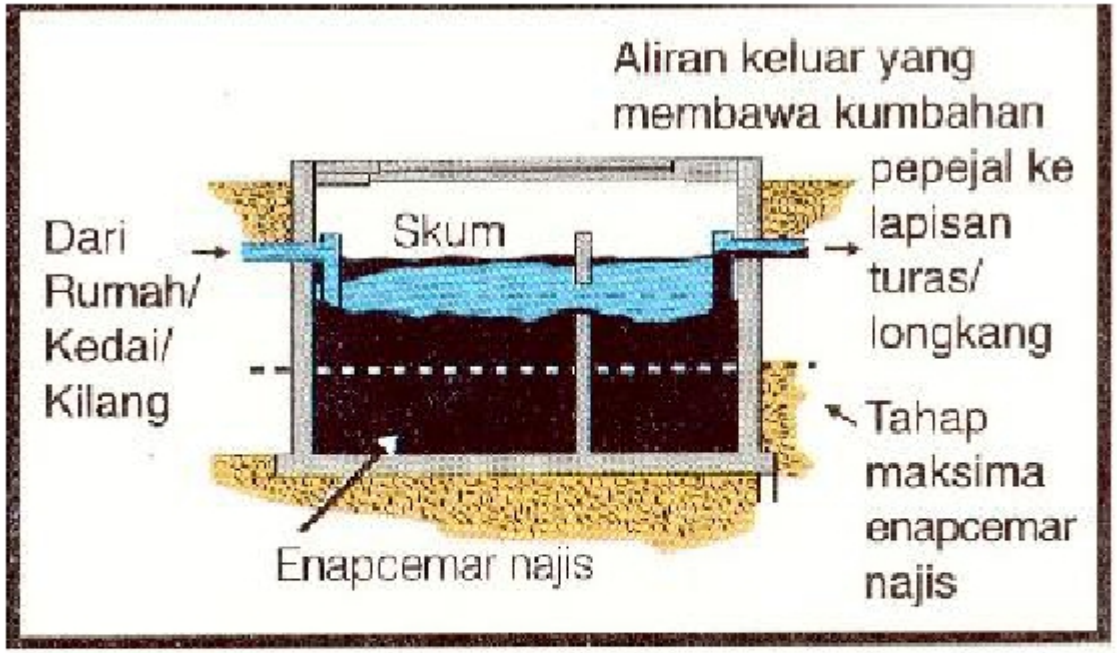
Ini adalah sebuah kolam rawatan kumbahan yang tidak beroperasi dan dipenuhi semak samun.

Removal of solids using septic tanks



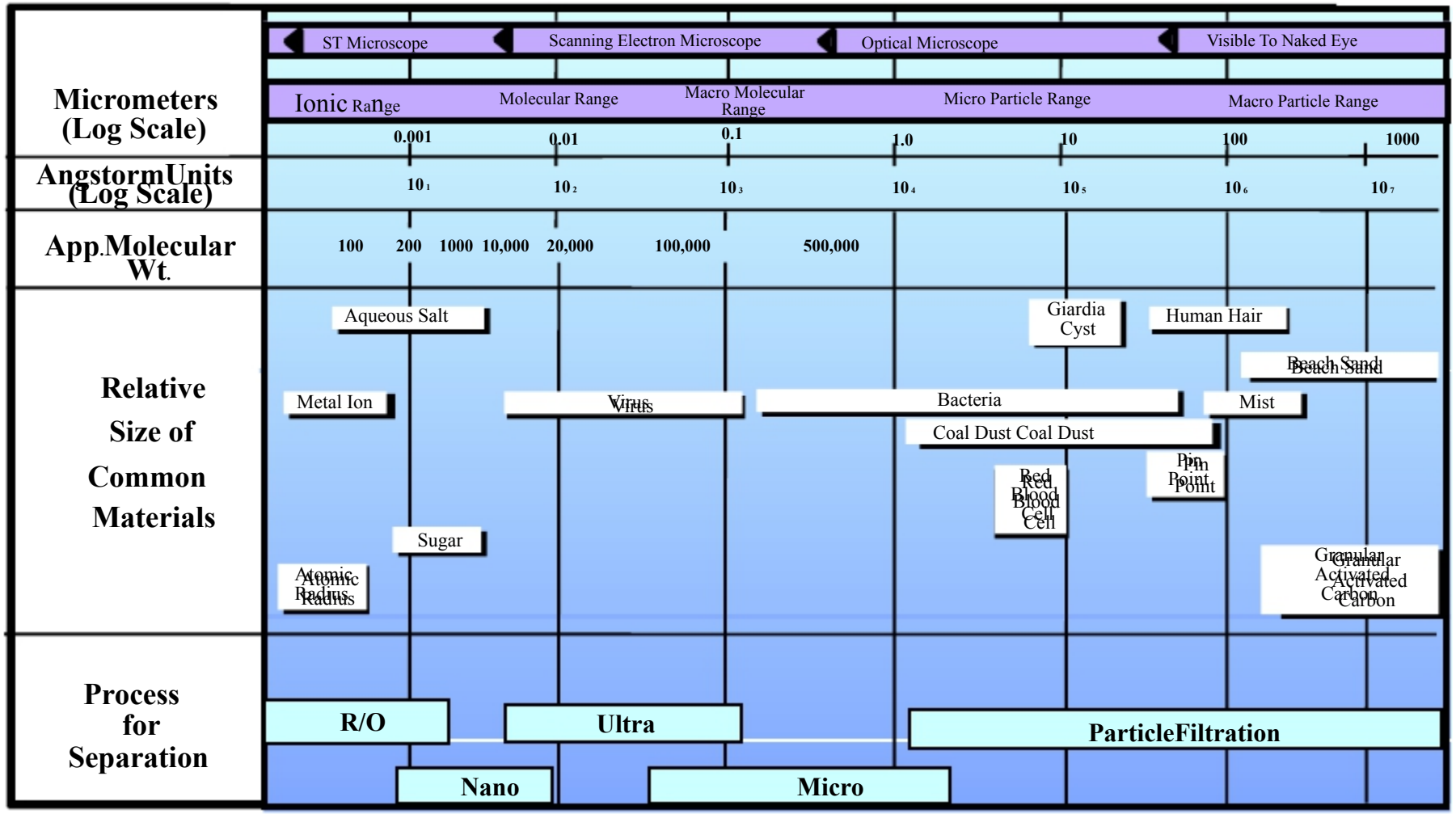
Isipadu maksima enapcemar najis yang boleh disimpan oleh tangki septik ialah lebih kurang satu pertiga jumlah isi kandungannya. Enapcemar najis tangki septik mestilah dikosongkan supaya ia tidak melebihi tahap maksima ini.

Removal of solids using septic tanks



Jika enapcemar najis melebihi tahap maksima, ia akan mengakibatkan rawatan kumbahan yang tidak lengkap dan kumbahan separa mentah mengalir keluar ke sistem pengairan kita.

Filtration spectrum



Example 1: Calculation of solids …

Q: A well-mixed 25 mL of raw wastewater is used for TS analyses. A well-mixed 50 mL of raw wastewater is used for SS analyses. Weights of evaporating dish with and without the sample either dried, evaporated, or ignited were determined to constant weight according to Standards Methods. The laboratory results are as follows:

Example 1: Calculation of solids …

Tare wt of evaporating dish = 42.2361 g

Wt of dish plus residue after evaporation at 105^{o}C = 42.4986 g

Wt of dish plus residue after ignition at 550^{o}C = 42.4863 g

Tare wt of filter plus Gooch crucible = 21.5308 g

Wt of residue and filter plus crucible after drying at 105^{o}C = 21.5447 g

Wt of residue and filter plus crucible after ignition at 550^{o}C = 21.5349 g

Compute the concentrations of TS, VS, FS, TSS, VSS, FSS.

Example 1: Solutions to calculation of solids …

Step 1: Determine total solid:

mg TS/L = [(A-B)x1000] / [sample volume, mL]

A = wt of dried residue plus dish = 42,498.6 mg

B = wt of dish = 42,472.3 mg

Sample = 25 mL

TS = [(42,498.6 – 42,472.3)] x [1000/25] mg/L

= 1050 mg/L

Example 1: Solutions to calculation of solids …

Step 2: Determine volatile solid:

mg volatile solid/L = [(G - H)x1000] / [sample volume, mL]

A = wt of residue plus crucible before ignition = 42,498.6 mg

H = wt of residue plus crucible or filter after ignition = 42,486.3 mg

Sample = 25 mL

VS = [(42,498.6 – 42,486.3)] x [1000/25] mg/L

= 492 mg/L

Example 1: Solutions to calculation of solids …

Step 3: Determine fixed solid:

FS = TS - VS

= 1050 – 492 = 558 mg/L

References

Sawyer C.N., McCarty P.L. & Parkin G.F. (2003) *Chemistry for Environmental Engineering*. Fifth Edition. McGraw-Hill, Singapore.

Shaw I.C. & Chadwick J. (1998) *Principles of Environmental Toxicology*. Taylor & Francis, London

Lester J.N. & Birkett (1999) Microbiology & Chemistry for Environmental Scientists & Enginees. E&FN Spon, London.