wastewater treatment (principals)

Concentration expressions

- MOLE (molecular weight)
- 1 mole of a substance is the quantity identical to the substance's atomic or molecular mass (atomic or molecular weight)
- 1 mol contains avogadro's number (6.023 x 10^{23}) of particles of the substance.

Number of moles

- Number of moles = wt/M.wt
- Wt= solute wheight
- M.wt = mole

Molarity (mole/l)

molarity= wt/mol.wt* 1000/volume(ml)

1 molar = 1 mole/l

1 mole/l = 1000mmole/l

Equivalent weight

- eq.wt= MW/valency
- Valency

Acids,bases,metals

Normality (eq/l)

normality= wt/equivalent wt*1000/volume(ml)

1 normal = 1 eq/l

1 eq/l=1000 meq/l

Relation between normality and molarity

- normality= molarity*valency

Part per million (ppm)

Parts per million (ppm) is how many parts a certain molecule or compound makes up within the one million parts of the whole solution. It is typically used to describe concentrations of chemicals dissolved in a solvent (typically water) or compounds in soil.

ppm x solution density = mg/L

Percentage %

$$\frac{weight}{volume}\% = \frac{weight\ of\ solute}{volume\ of\ solution} \times 100$$

$$\frac{weight}{weight}\% = \frac{weight\ of\ solute}{weight\ of\ solution} \times 100$$

$$\frac{volume}{volume}\% = \frac{volume\ of\ solute}{volume\ of\ solution} \times 100$$

Convert percentage to molar

The Molarity Calculator Equation:

The following equation is used for calculating Molarity where the concentration is given in wt %:

[(% x d) / MW] x 10 = Molarity

Where: % = Weight %; d = Density (or specific gravity); MW = Molecular Weight (or Formula Weight).

The above equation can then be used to calculate the Molarity of the 70 wt % Nitric Acid:

[(70 x 1.413) / 63.01] x 10 = 15.7 M

Calcium carbonate equivalents (mg/L as $CaCO_3$)	A method for expressing mg/L as ion in terms of calcium carbonate. Concentration in calcium carbonate equivalents is calculated by multiplying concentration in mg/L of the ion by the equivalent weight of calcium carbonate (50) and dividing by the equivalent weight of the ion.

Famous expression

Hydrochloric Acid Standard Solution, 6.0 N (1:1)

It means take one volume of concentrated hydrochloride acid and mix with one volume of water, doesn't matter what the volume is, it is the same as 50% dilution. For example 10mL of acid mixed with 10mL of water is a **1:1** dilution or a 1+1 dilution or a 50% dilution.

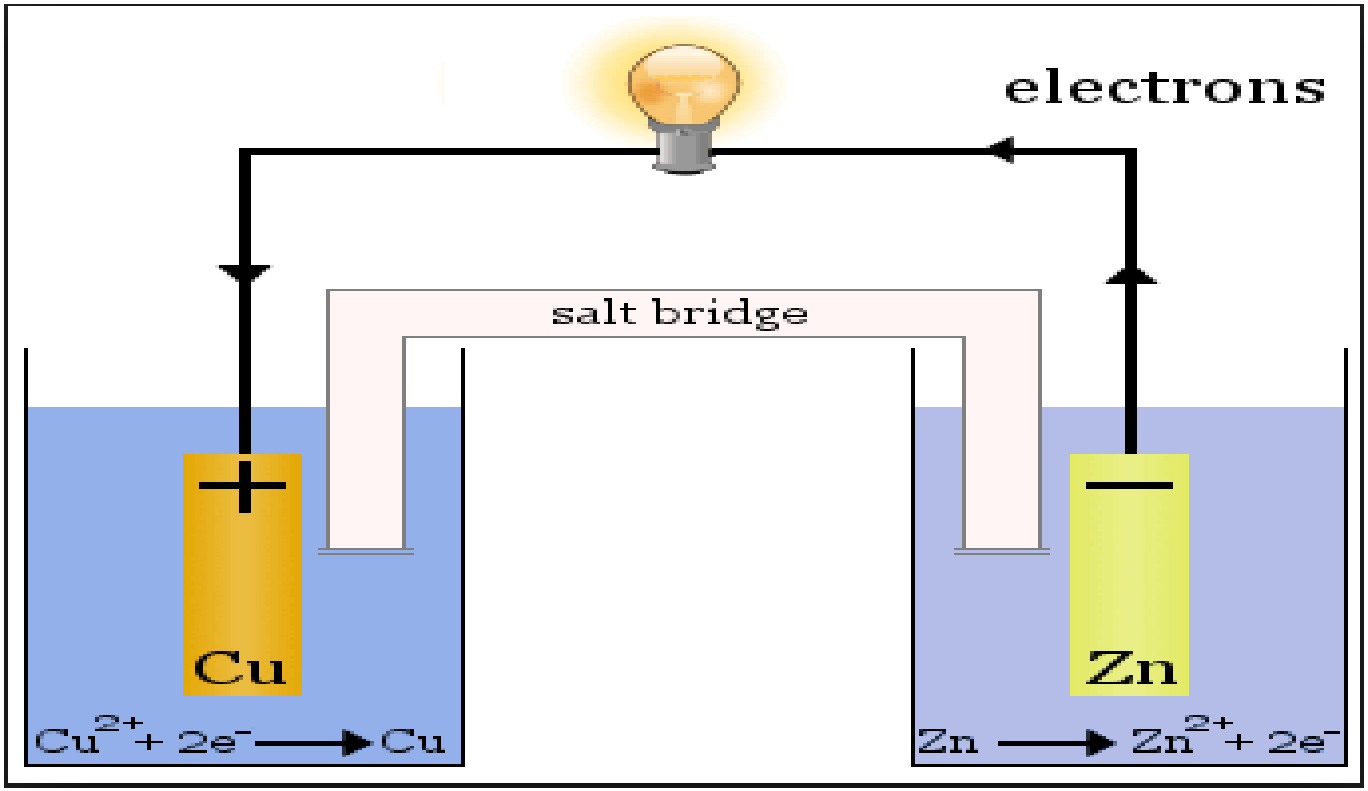
Dilution law

- $C_1 * V_1 = C_2 * V_2$

ANALOG AND DIGITAL SIGNALS

- 5-0 VOLTS (DIGITAL SIGNAL)
- WHAT ABOUT IN BETWEEN 3 VOLTS FOR EXAMPLE (ITS ANALOG SIGNAL)
- HOW CAN I READ IT ON A DEVICE (SO EASY IN THE MICRO PROCESSOR OF The DEVICE THERE IS ANALOG TO DIGITAL CONVERTER UNIT SO YOU CAN READ IT AS A DIGITAL VALUE)

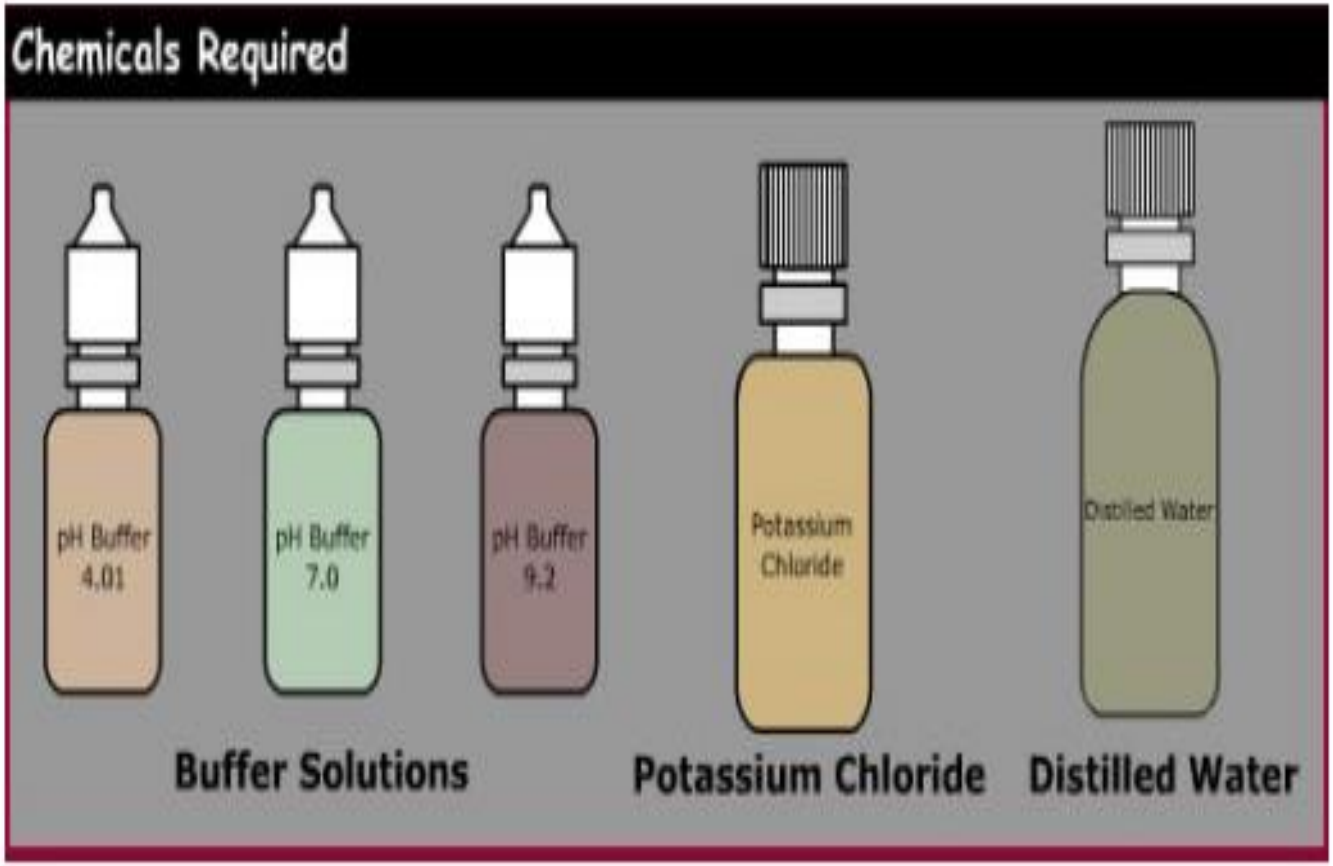
ELECTROCHEMICAL CELL



PRINCIPLE

The pH electrode used in the pH measurement is a combined glass electrode. It consists of sensing half cell and reference half cell, together form an electrode system. The sensing half cell is a thin pH sensitive semi permeable membrane, separating two solutions, viz., the outer solution, the sample to be analyzed and the internal solution, enclosed inside the glass membrane and has a known pH value. An electrical potential is developed inside and another electrical potential is developed outside, the difference in the potential is measured and is given as the pH of the sample.

CALIBRATE AND MEASURE



STORE

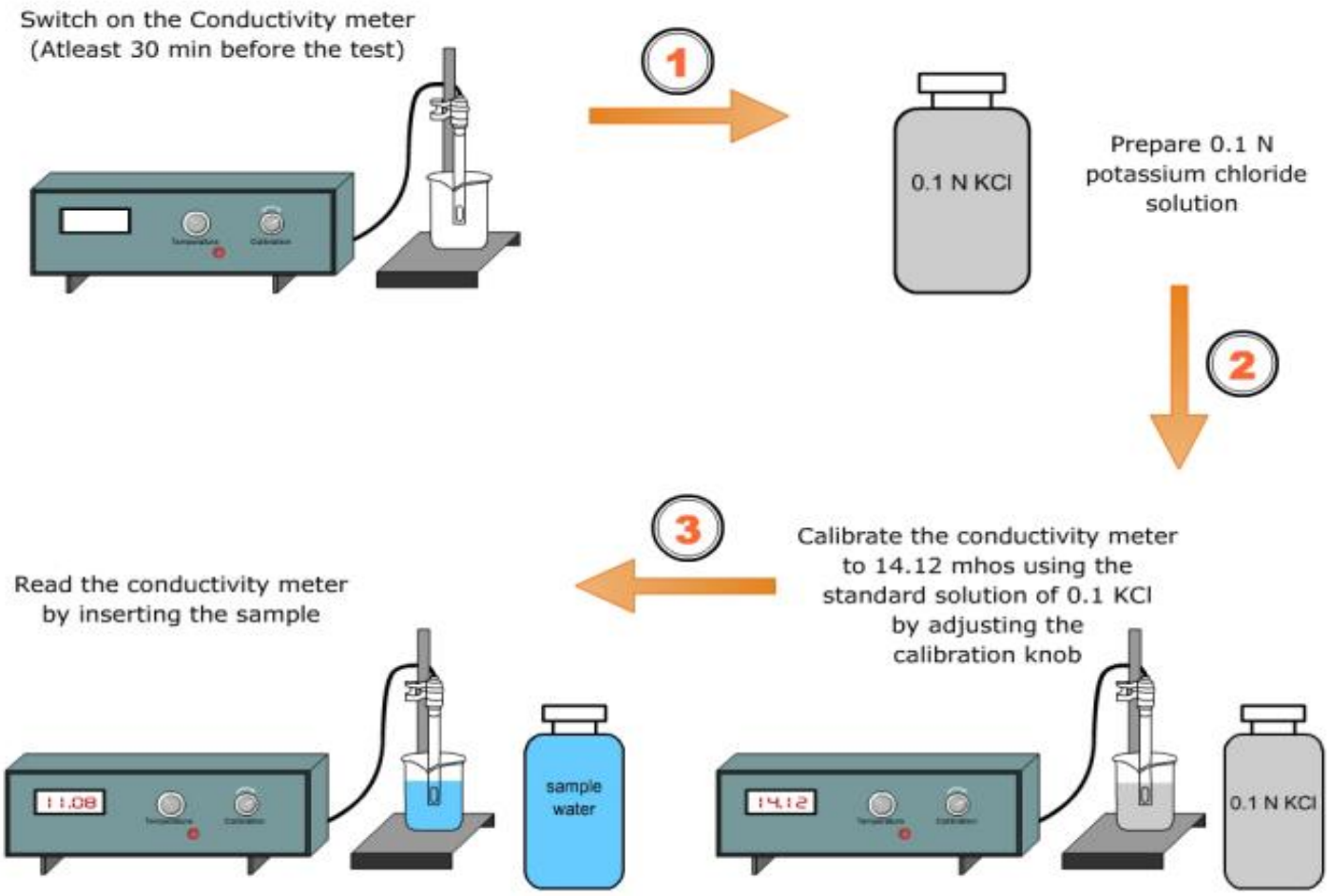
- Always keep your pH electrode moist. We recommend that you store your electrode in a solution of 4 M KCl. If 4 M KCl is not available, use a pH 4 or 7 buffer solution. DO NOT store electrode in distilled or deionized water this will cause ions to leach out of the glass bulb and render your electrode useless.

- After storage, you may notice white KCl crystals forming outside your electrode. This will not interfere with measurements. Simply rinse the electrode and blot dry before use.

TEMPERATURE & PH RLATIONSHIP

T (°C)	K_w ($mol^2\ dm^{-6}$)	pH	pOH
0	0.114×10^{-14}	7.47	7.47
10	0.293×10^{-14}	7.27	7.27
20	0.681×10^{-14}	7.08	7.08
25	1.008×10^{-14}	7.00	7.00
30	1.471×10^{-14}	6.92	6.92
40	2.916×10^{-14}	6.77	6.77
50	5.476×10^{-14}	6.63	6.63

CONDUCTIVITY



TDS & CONDUCTIVITY RLATIONSHIP

- The conversion factor ranges from 0.55 to 0.8, but as a suitable approximation you can use the formula TDS (mg/l) = 0,67*EC (µS/cm), which is valid up to 2000 µS/cm.
- MAY USE GRAVIMETRIC METHOD AND DETERMINE TDS AND PRODUCE YOUR FACTOR

LENNTECH

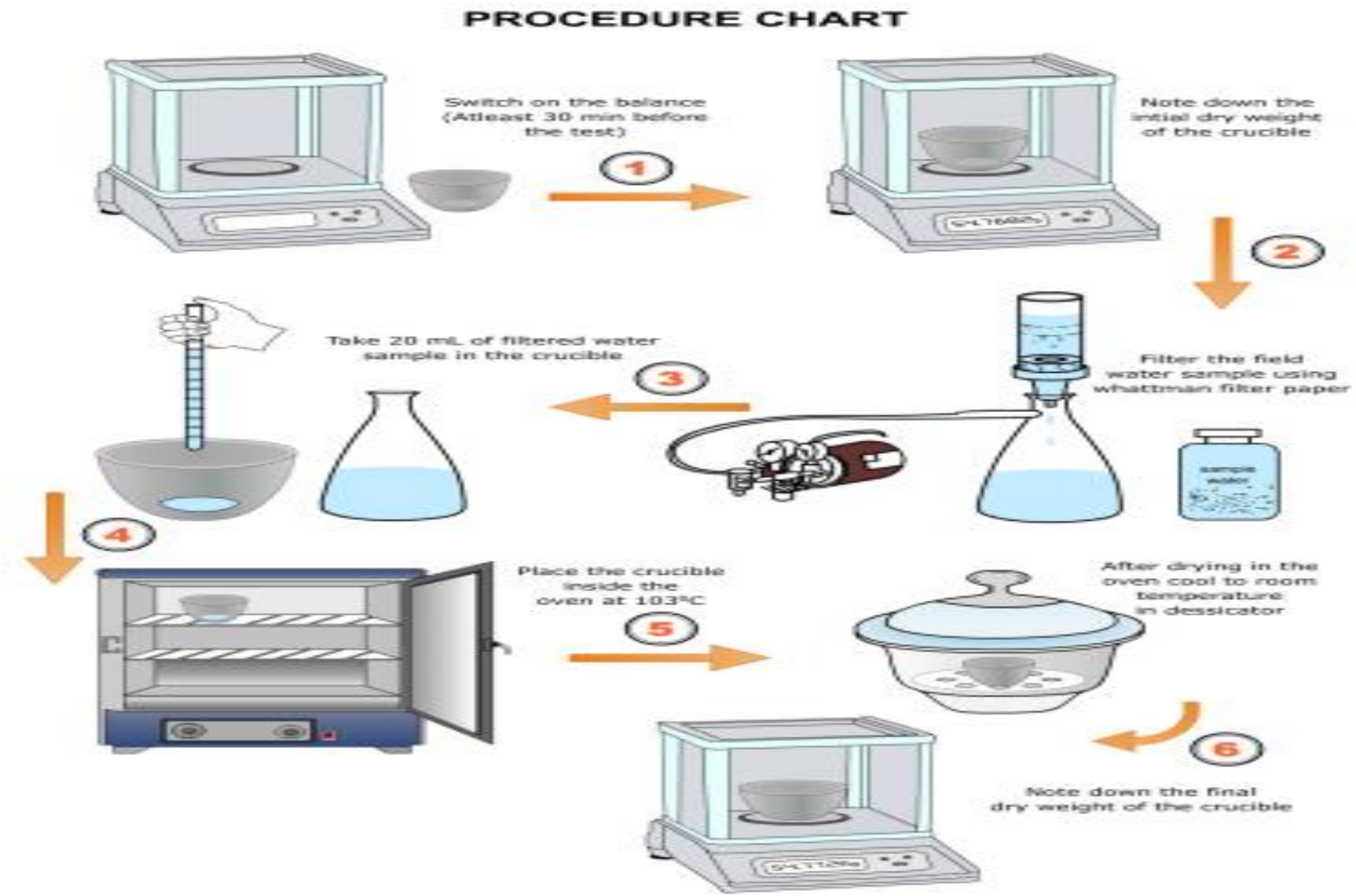
Input:	1500	microS/cm ▾
S/cm	0.00150	
mS/cm	1.50	
microS/cm	1.50e+3	
EC	1.50	**mS/cm** [1)]
CF	15.0	
mho/cm	0.00150	
mho/m	0.0000150	
ppm TDS	960	

Calculate

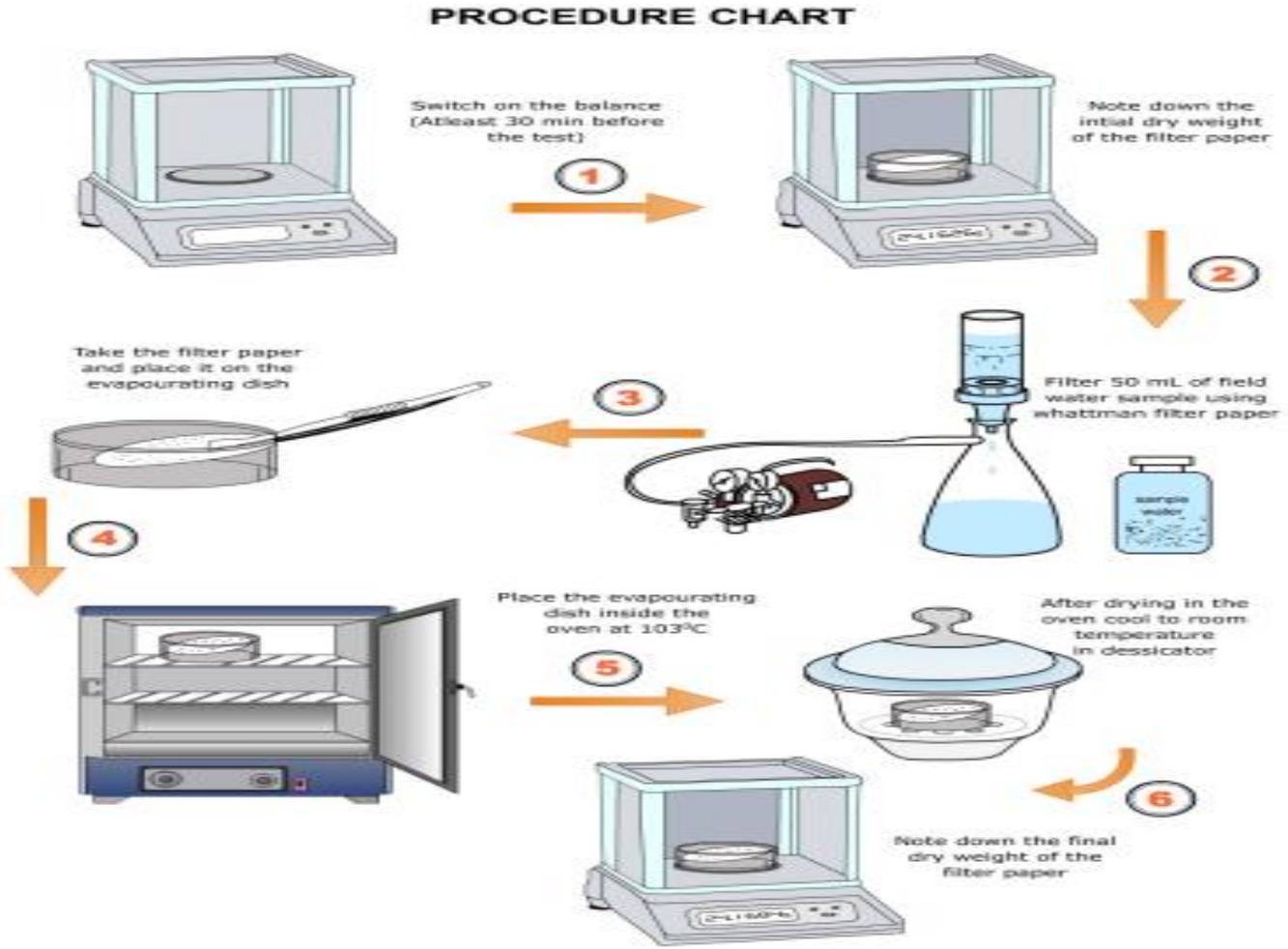
SOLIDS TESTS

- TAKE IN CONSIDERATION FOR OPTIMUM CALCULATIONS
- 1- CRUCIBLE WHEIGHT
- 2- FILTER PAPER WHEIGHT

TOTAL DISSOLVED SOLIDS (TDS)

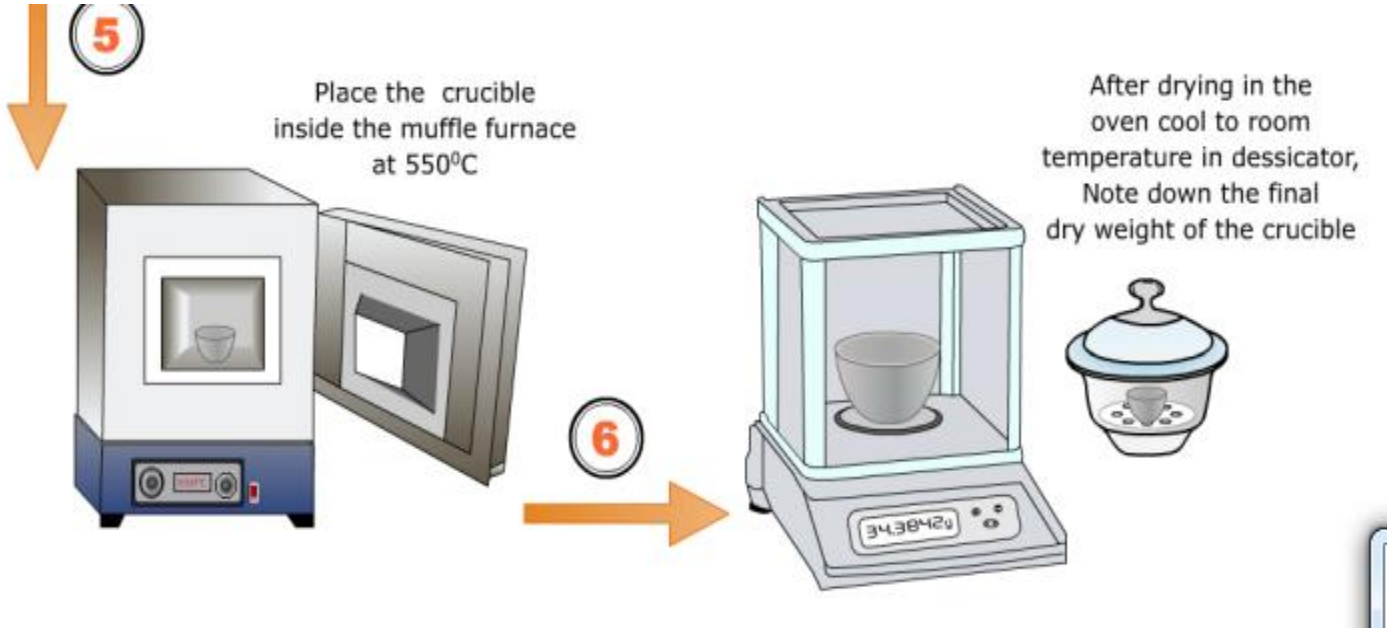


TOTAL SUSPENDED SOLIDS (TSS)

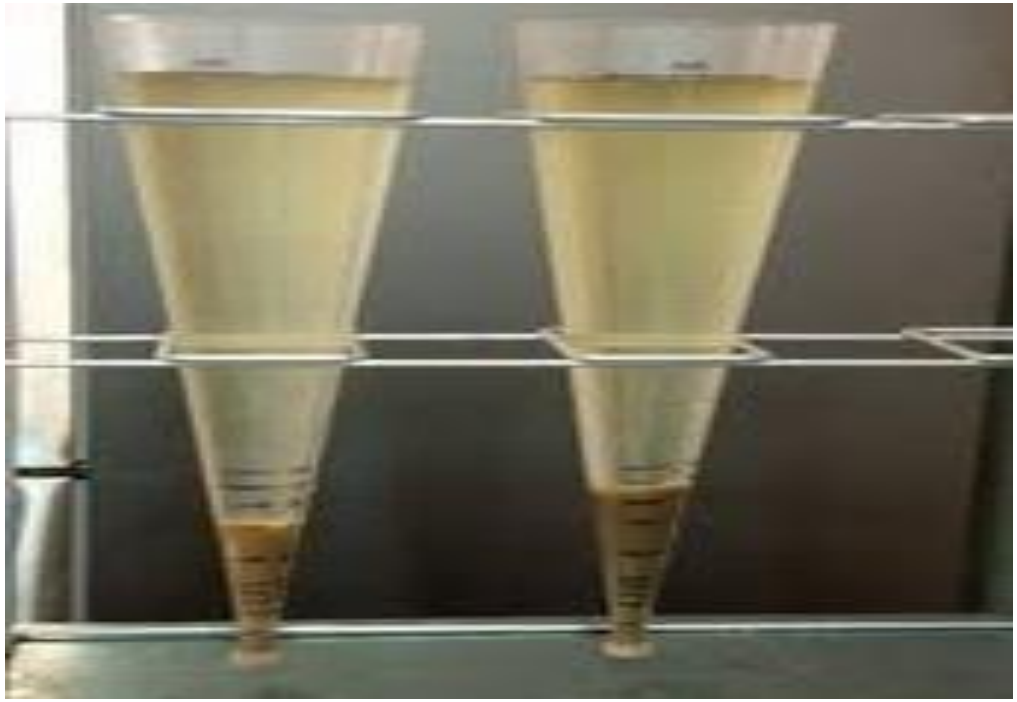


VOLATILE SUSPNDWD SOLIDS (VSS)

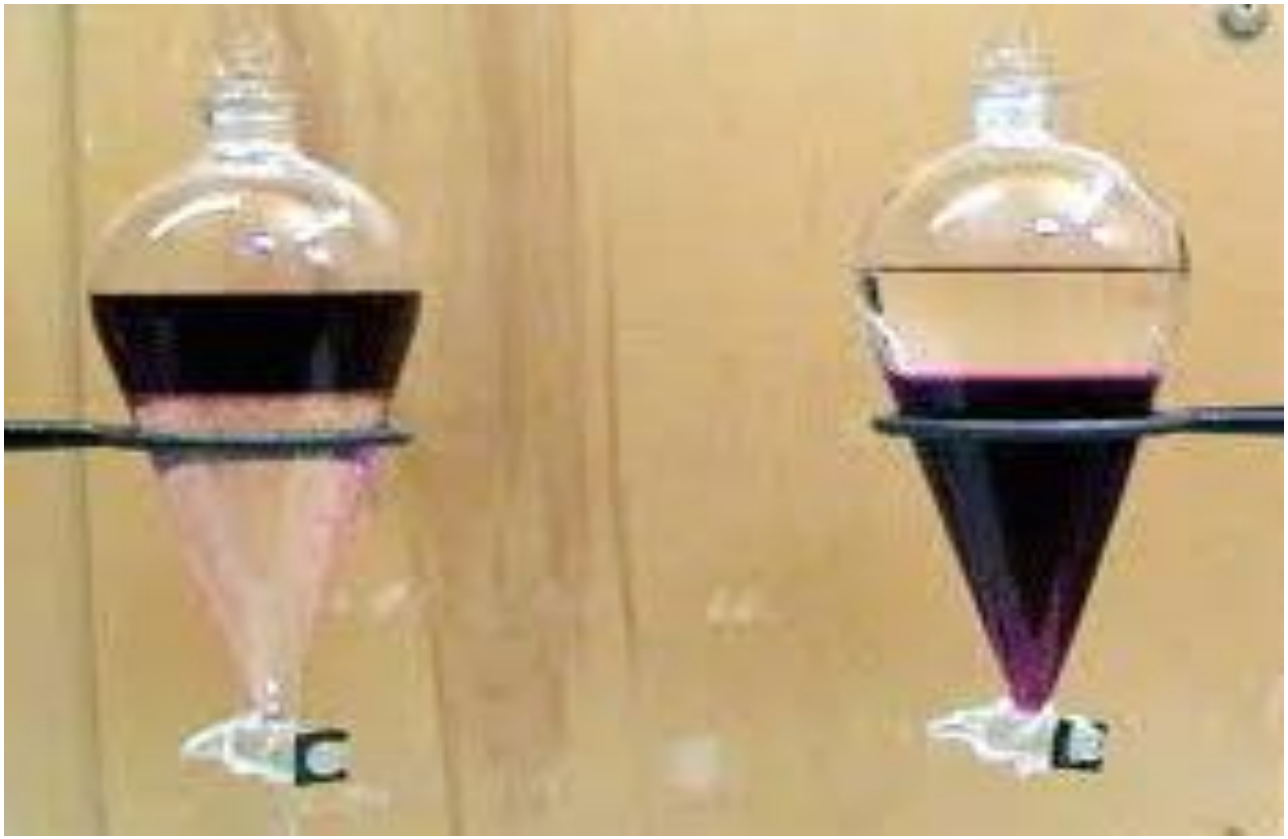
CRUCIBLE CONTAIN FILTER PAPER



SETTLABLE SOLIDS

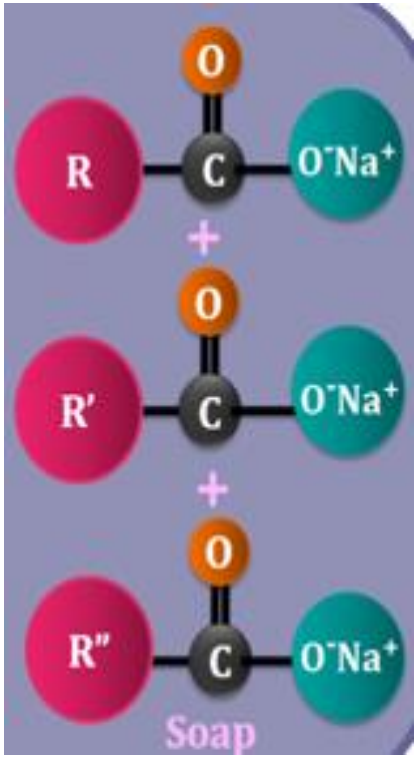


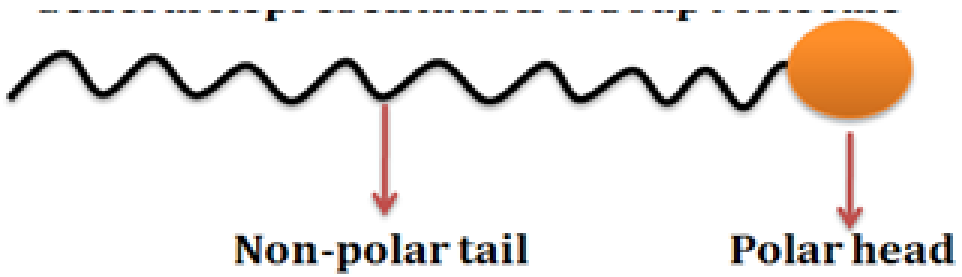
Like dissolves like

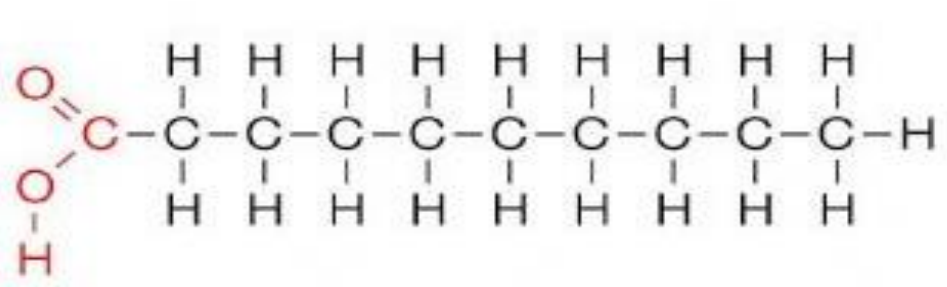


OIL&GREASE

- Emulsifying agent (soap and other detergents)





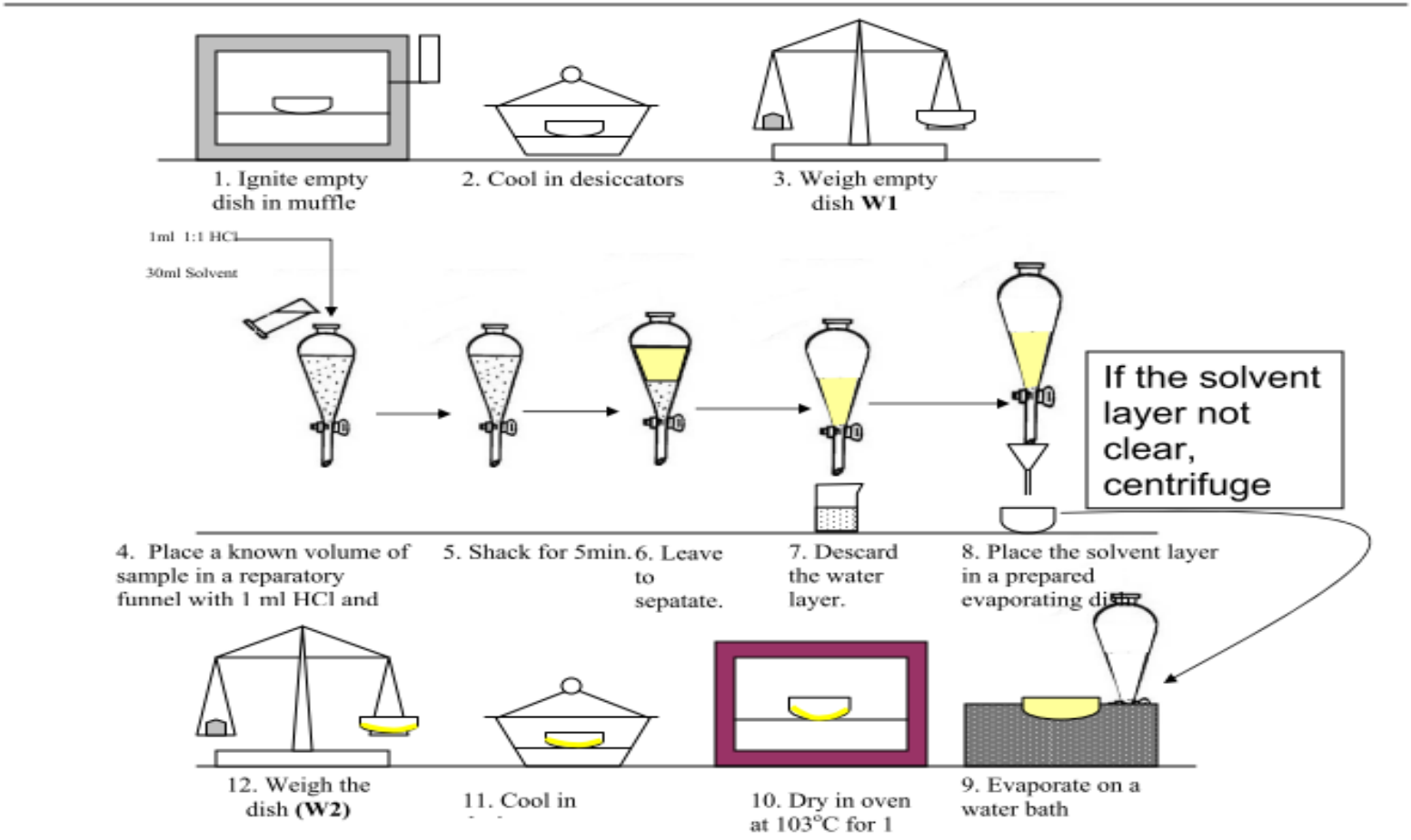


OIL&GREASE TEST

- Principle

- Dissolved or emulsified oil and grease is extracted from water by intimate contact with n-hexane, petroleum ether

OIL&GREASE TEST



DISSOLVED OXYGEN

CALIBRATION

If using the ProBOD sensor/cable assembly, place the probe in 300 ml BOD bottle with a small amount of water (1/8 inch or 0.3 cm). The dissolved oxygen and temperature sensors should not be immersed in water.

Calibration Tables

Table I shows the amount of oxygen in mg/L that is dissolved in air saturated fresh water at sea level (760 mmHg atmospheric pressure) as temperature varies from 0° to 45°C.

Table I - Solubility of Oxygen in Fresh Water

Temp °C	Solubility mg/L	Temp °C	Solubility mg/L	Temp °C	Solubility mg/L
0	14.62	17	9.67	34	7.07
1	14.22	18	9.47	35	6.95
2	13.83	19	9.28	36	6.84
3	13.46	20	9.09	37	6.73
4	13.11	21	8.92	38	6.62
5	12.77	22	8.74	39	6.52
6	12.45	23	8.58	40	6.41
7	12.14	24	8.42	41	8.31
8	11.84	25	8.26	42	6.21
9	11.56	26	8.11	43	6.12
10	11.29	27	7.97	44	6.02
11	11.03	28	7.83	45	5.93
12	10.78	29	7.69	46	5.84
13	10.54	30	7.56	47	5.74
14	10.31	31	7.43	48	5.65
15	10.08	32	7.31	49	5.56
16	9.87	33	7.18	50	5.47

Temp °C	Chlorinity: 0 Salinity: 0	5.0 9.0	10.0 18.1	15.0 27.1	20.0 36.1	25.0 45.2
0.0	14.62	13.73	12.89	12.10	11.36	10.66
1.0	14.22	13.36	12.55	11.78	11.07	10.39
2.0	13.83	13.00	12.22	11.48	10.79	10.14
3.0	13.46	12.66	11.91	11.20	10.53	9.90
4.0	13.11	12.34	11.61	10.92	10.27	9.66
5.0	12.77	12.02	11.32	10.66	10.03	9.44
6.0	12.45	11.73	11.05	10.40	9.80	9.23
7.0	12.14	11.44	10.78	10.16	9.58	9.02
8.0	11.84	11.17	10.53	9.93	9.36	8.83
9.0	11.56	10.91	10.29	9.71	9.16	8.64
10.0	11.29	10.66	10.06	9.49	8.96	8.45
11.0	11.03	10.42	9.84	9.29	8.77	8.28
12.0	10.78	10.18	9.62	9.09	8.59	8.11
13.0	10.54	9.96	9.42	8.90	8.41	7.95
14.0	10.31	9.75	9.22	8.72	8.24	7.79
15.0	10.08	9.54	9.03	8.54	8.08	7.64
16.0	9.87	9.34	8.84	8.37	7.92	7.50
17.0	9.67	9.15	8.67	8.21	7.77	7.36
18.0	9.47	8.97	8.50	8.05	7.62	7.22
19.0	9.28	8.79	8.33	7.90	7.48	7.09
20.0	9.09	8.62	8.17	7.75	7.35	6.96
21.0	8.92	8.46	8.02	7.61	7.21	6.84
22.0	8.74	8.30	7.87	7.47	7.09	6.72
23.0	8.58	8.14	7.73	7.34	6.96	6.61
24.0	8.42	7.99	7.59	7.21	6.84	6.50
25.0	8.26	7.85	7.46	7.08	6.73	6.39
26.0	8.11	7.71	7.33	6.96	6.62	6.29
27.0	7.97	7.58	7.20	6.85	6.51	6.18
28.0	7.83	7.44	7.08	6.73	6.40	6.09
29.0	7.69	7.32	6.96	6.62	6.30	5.99
30.0	7.56	7.19	6.85	6.51	6.20	5.90
31.0	7.43	7.07	6.73	6.41	6.10	5.81
32.0	7.31	6.96	6.62	6.31	6.01	5.72
33.0	7.18	6.84	6.52	6.21	5.91	5.63
34.0	7.07	6.73	6.42	6.11	5.82	5.55
35.0	6.95	6.62	6.31	6.02	5.73	5.46
36.0	6.84	6.52	6.22	5.93	5.65	5.38
37.0	6.73	6.42	6.12	5.84	5.56	5.31
38.0	6.62	6.32	6.03	5.75	5.48	5.23
39.0	6.52	6.22	5.93	5.66	5.40	5.15
40.0	6.41	6.12	5.84	5.58	5.32	5.08
41.0	6.31	6.03	5.75	5.49	5.24	5.01
42.0	6.21	5.93	5.67	5.41	5.17	4.93
43.0	6.12	5.84	5.58	5.33	5.09	4.86
44.0	6.02	5.75	5.50	5.25	5.02	4.79
45.0	5.93	5.67	5.41	5.17	4.94	4.72

IMPORTANT

Zero Oxygen Solution for Zero Point Calibration

1. Perform a water-saturated air calibration.

2. Prepare a sodium sulfite solution by dissolving about 15.0 g of Na_2SO_3 in about 250 mL of distilled water. Transfer the solution to a BOD bottle or flask.

   Note: *A small amount of cobalt salt can be added to the sodium sulfite solution. The cobalt salt will act as an indicator and change color when the sodium sulfite solution no longer has a zero oxygen content.*

Why oxygen is consumed in water

$NH_4^+ + O_2 + \text{microorganisms} \rightarrow NO_2^- + H_2O$
(nitrosomonas bacteria)

$NO_2^- + O_2 + \text{microorganisms} \rightarrow NO_3^- + H_2O$
(nitrobacter bacteria)

Organics + O_2 + microorganisms → CO_2 + H_2O
(food) (heterotrophic bacteria)

$Fe^{+2} + O_2 \dashrightarrow Fe^{+3}$

$S^{-2} + O_2 \dashrightarrow SO_4^{-2}$

BOD

The sample is filled in an airtight bottle and incubated at specific temperature for 5 days. The dissolved oxygen (DO) content of the sample is determined before and after five days of incubation at 20°C and the BOD is calculated from the difference between initial and final DO.

The initial DO is determined shortly after the dilution is made; all oxygen uptake occurring after this measurement is included in the BOD measurement.

Nutrients preparation

- 1- Magnesium sulfate solution: prepared by dissolving 22.5 g MgSO4.7H2O in distilled water and diluted to1L.
- 2- Calcium chloride solution: prepared by dissolving 27.5 g CaCl2 in distilled water and diluted to1L.
- 3- Ferric chloride solution: prepared by dissolving 0.25 g FeCl 3.6H2O in Distilled water and diluted to1L.
- 4- Phosphate buffer solution: prepared by dissolving 8.5 g KH2PO4, 21.75 g K2HPO4, 33.4 g Na2HPO4.7H2O, and1.7g NH4Cl in 500mL distilled water and diluted to1L.

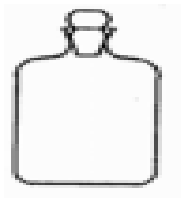
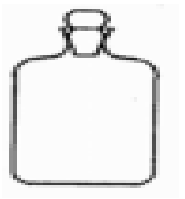
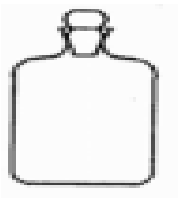
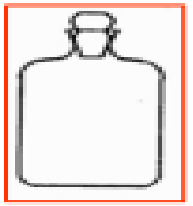
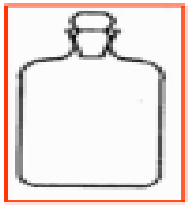
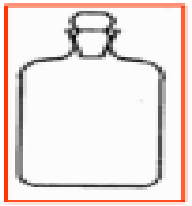
Dilution water

- One milliliter of each solution should be added for each liter of dilution water. In this example, if 10 liters of dilution water is being prepared, 10 ml of each nutrient solution should be added.

How we can dilute

Volume added	Expected BOD
3	200 - 560 mg/L
6	105 - 280
9	70 - 187
12	53 - 140
15	42 - 112
30	21 - 56
45	14 - 37
60	11 - 28
100	5 - 15
300	0 - 5

Procedure scheme

		
		
Blank	1st Dilution	2nd Dilution

calculations

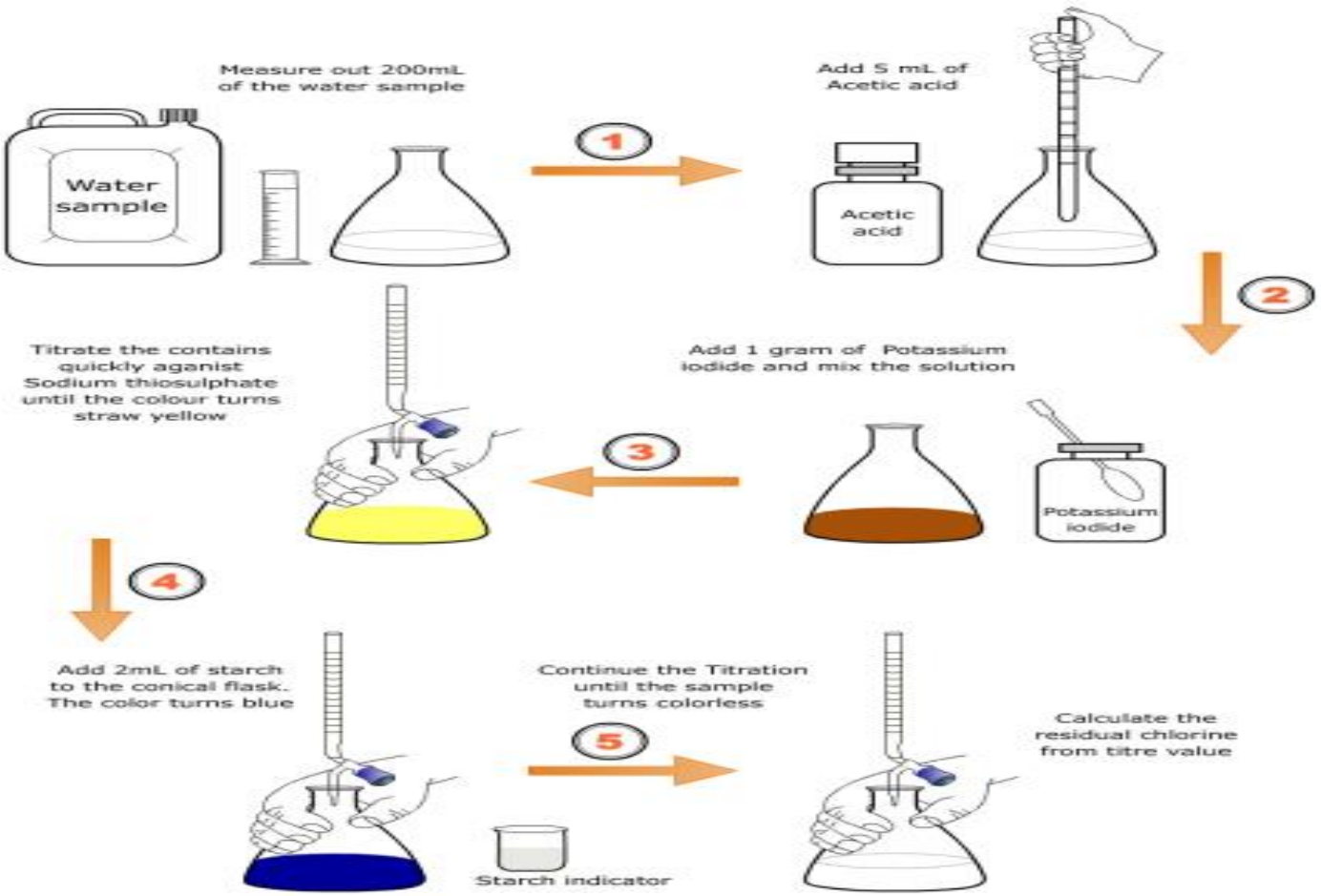
BOD calculations follow the general formula:

$$BOD = \frac{\text{DO used by sample} \times 300}{\text{Sample volume}}$$

DO Depletion Rule

The final day 5 DO must drop at least 2 mg/L from the initial DO and be greater than 1 mg/L

Chlorinated sample



Chlorinated sample

CHEMICALS REQUIRED

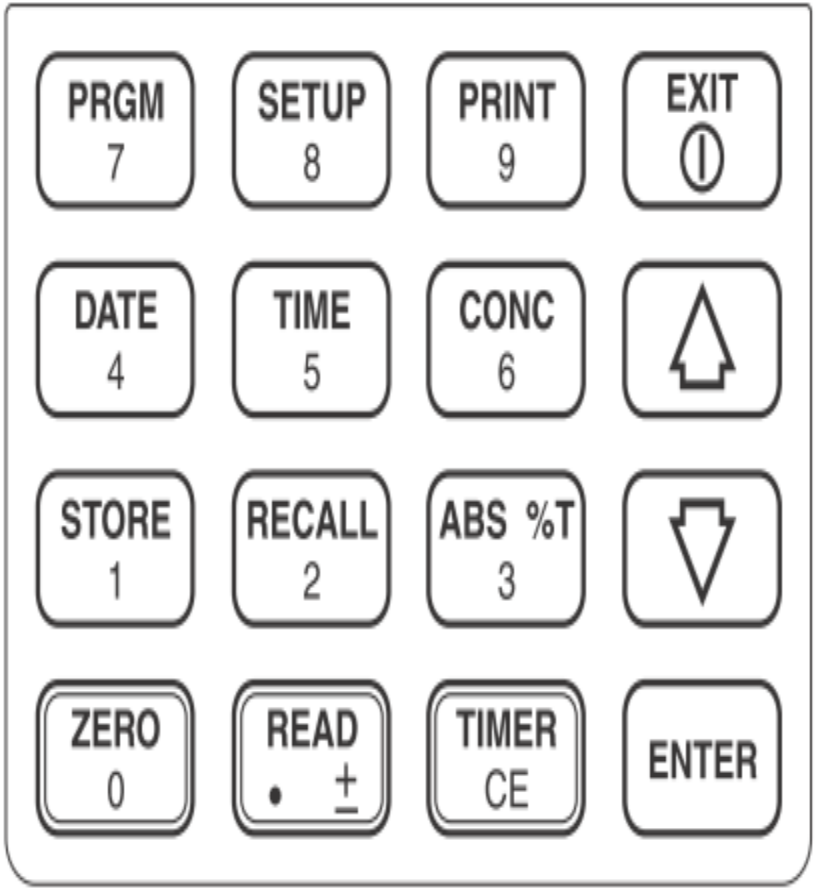
1. Acetic Acid, Conc. (glacial)
2. Potassium Iodide, KI, crystals
3. Sodium thiosulphate
4. Starch indicator
5. Distilled or Deionized Water

Chlorinated sample

Blue color is titrated to clear using sodium sulfite

DR 800


HACH
DR/890 Colorimeter


PRGM
7
SETUP
8
PRINT
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TIME
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6
STORE
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READ
• ±
TIMER
CE
ENTER

COD

OXYGEN DEMAND, CHEMICAL

Method 8000
For water, wastewater and seawater

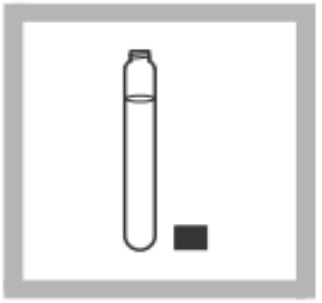
Reactor Digestion Method* USEPA approved for reporting wastewater analysis**
Digestion

1. Homogenize 500 mL of sample for 2 minutes in a blender.

Note: For the 0-15,000 mg/L range, *homogenize 100 mL of sample. Pour the blended sample into a 250-mL beaker. Stir with a magnetic stirrer while withdrawing a sample aliquot. This improves accuracy and reproducibility.*

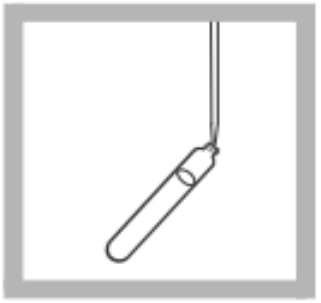
2. Turn on the DRB 200 Reactor. Preheat to 150 °C.

Note: *See DRB 200 user manual for selecting pre-programmed temperature applications.*



3. Remove the cap of a COD Digestion Reagent Vial for the appropriate range:

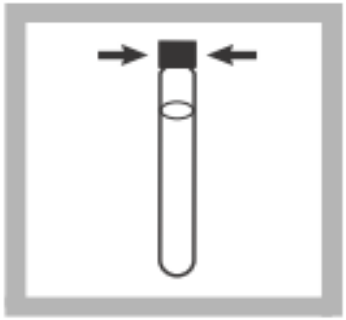
Sample Conc. Range (mg/L)	COD Digestion Reagent Vial Type
0 to 150	Low Range
0 to 1500	High Range
0 to 15,000	High Range Plus



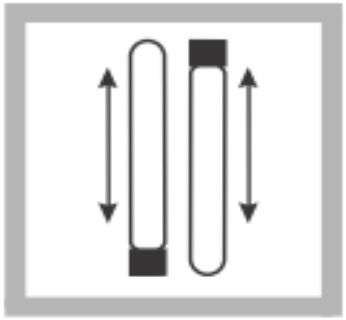
4. Hold the vial at a 45-degree angle. Pipet 2.00 mL (0.2 mL for the 0 to 15,000 mg/L range) of sample into the vial.

Note: For the 0-15,000 mg/L range, *pipet only 0.20 mL of sample, not 2.00 mL of sample, using a TenSette Pipet. For greater accuracy analyze a minimum of three replicates and average the results.*

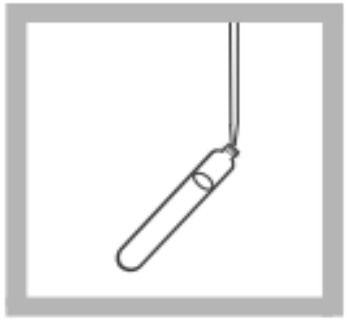
COD



5. Replace the vial cap tightly. Rinse the outside of the COD vial with deionized water and wipe the vial clean with a paper towel.

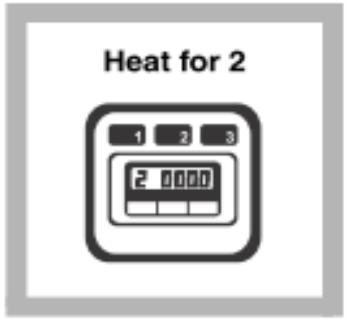


6. Hold the vial by the cap and over a sink. Invert gently several times to mix the contents. Place the vial in the preheated DRB 200 Reactor.
Note: *The vial will become very hot during mixing.*



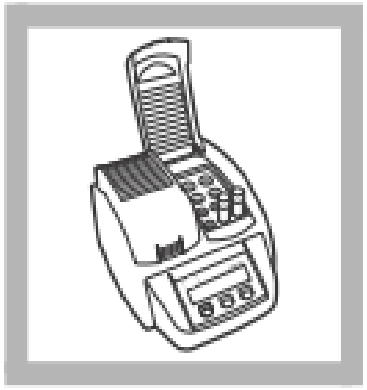
7. Prepare a blank by repeating Steps 3 to 6, substituting 2.00 mL (0.2 mL for the 0 to 15,000 mg/L range) deionized water for the sample.
Note: *Be sure the pipet is clean.*

Note: *One blank must be run with each set of samples. Run samples and blanks with vials from the same lot number (lot # is on the container label).*

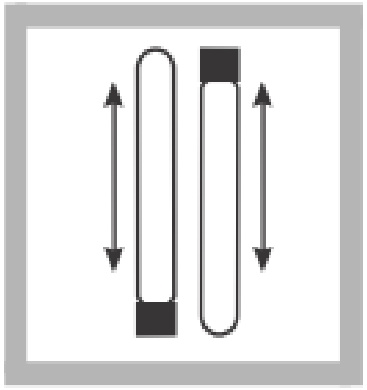


8. Heat the vials for 2 hours.
Note: *Many samples are digested completely in less than two hours. If desired, measure the concentration (while still hot) at 15 minute intervals until the reading remains unchanged. Cool vials to room temperature for final measurement.*

COD

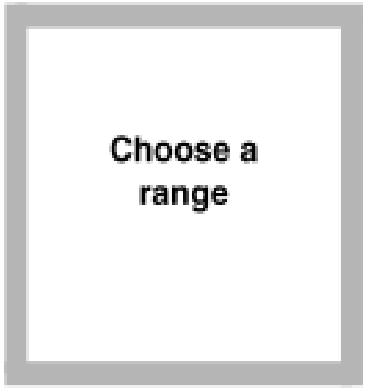


9. Turn the reactor off. Wait about 20 minutes for the vials to cool to 120 °C or less.



10. Invert each vial several times while still warm. Place the vials into a rack. Wait until the vials have cooled to room temperature.

Note: *If a pure green color appears in the reacted sample, measure the COD and, if necessary, repeat the test with a diluted sample.*

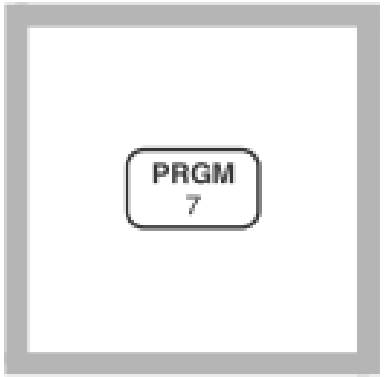


11. Use one of the following analytical techniques to measure the COD:

- Colorimetric method, 0-150 mg/L COD
- Colorimetric method, 0-1,500 mg/L COD
- Colorimetric method, 0-15,000 mg/L COD

COD

Colorimetric Determination, 0 to 150 mg/L COD

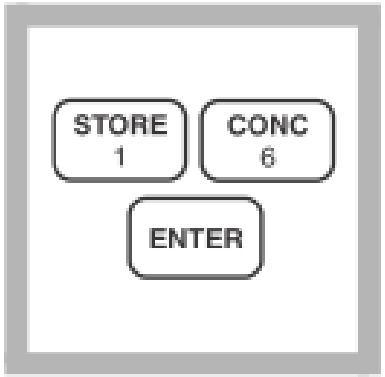


1. Enter the stored program number for chemical oxygen demand (COD), low range.

Press: **PRGM**

The display will show:

PRGM ?



2. Press: **16 ENTER**

The display will show **mg/L, COD** and the **ZERO** icon.

Note: *For alternate form (O_2), press the* **CONC** *key.*

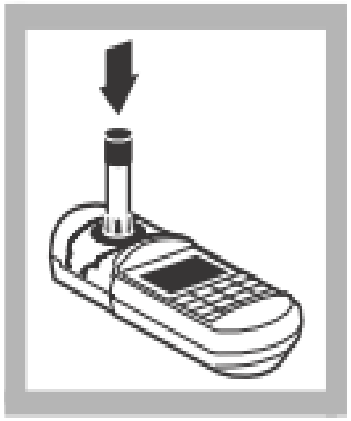
3. Insert the COD/TNT Adapter into the cell holder by rotating the adapter until it drops into place. Then push down to fully insert it.

Note: *For increased performance, a diffuser band covers the light path holes on the adapter. Do not remove the diffuser band.*

4. Clean the outside of the blank with a towel.

Note: *Wiping with a damp towel, followed by a dry one, will remove fingerprints or other marks.*

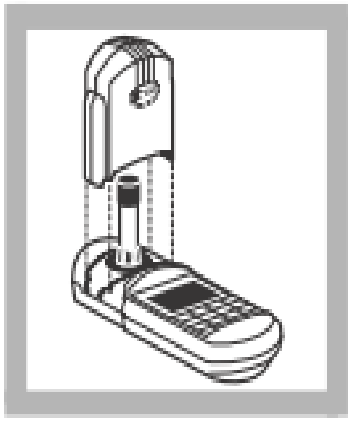
COD



5. Place the blank in the adapter.

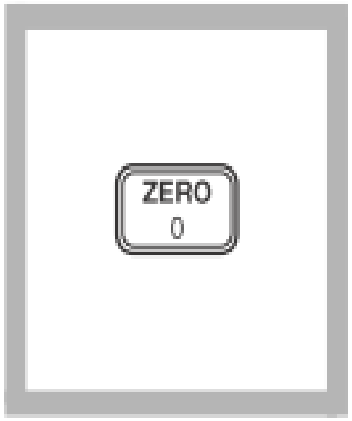
Push straight down on the top of the vial until it seats solidly into the adapter.

Note: *Do not move the vial from side to side as this can cause errors.*



6. Tightly cover the vial with the instrument cap.

Note: *The blank is stable when stored in the dark. See Blanks for Colorimetric Determination following these procedures.*



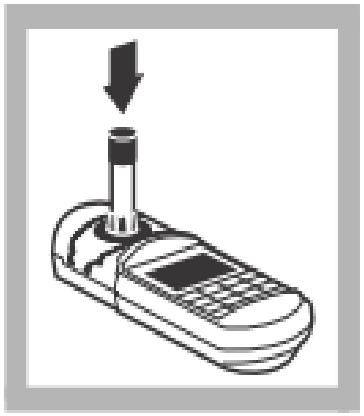
7. Press: **ZERO**

The cursor will move to the right, then the display will show:

0 mg/L COD

8. Clean the outside of the sample vial with a towel.

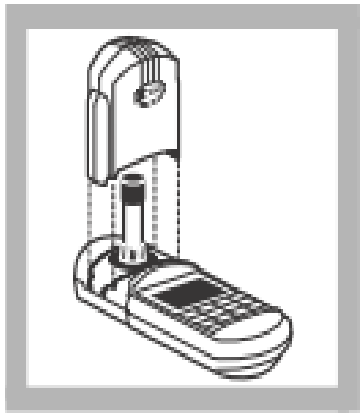
COD



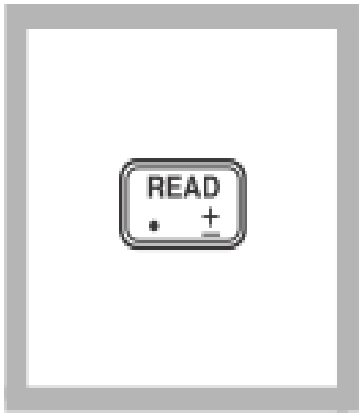
9. Place the sample vial in the adapter.

Push straight down on the top of the vial until it seats solidly into the adapter.

Note: *Do not move the vial from side to side as this can cause errors.*



10. Tightly cover the vial with the instrument cap.



11. Press: **READ**

The cursor will move to the right, then the result in mg/L COD will be displayed.

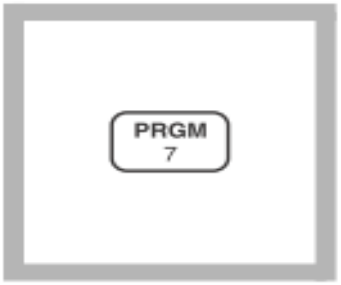
Residual chlorine (free)

Method 8021

CHLORINE, FREE (0 to 2.00 mg/L) **For water, wastewater, and seawater**

DPD Method (Powder Pillows or AccuVac Ampuls)
USEPA accepted for reporting wastewater and drinking water analyses*

Using Powder Pillows



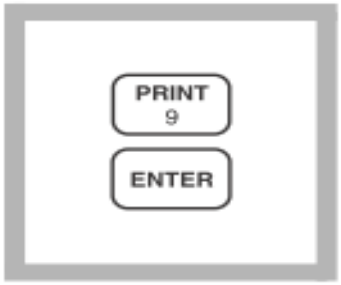
1. Enter the stored program number for free and total chlorine (Cl_2) powder pillows.

Press: **PRGM**

The display will show:

PRGM ?

Note: *For most accurate results, perform a Reagent Blank Correction using deionized water (see Section 1).*



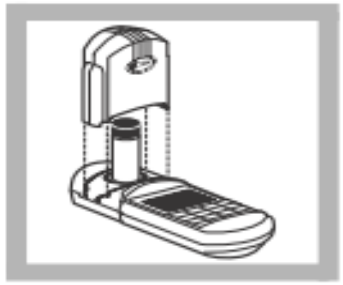
2. Press: **9 ENTER**

The display will show **mg/L, Cl2** and the **ZERO** icon.

3. Fill a sample cell with 10 mL of sample (the blank).

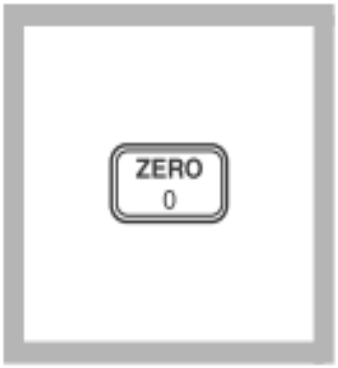
Note: *Samples must be analyzed immediately and cannot be preserved for later analysis.*

Note: *The SwifTest Dispenser for Free Chlorine can be used in place of the powder pillows in step 7.*



4. Place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.

Residual chlorine (free)



5. Press: **ZERO**

The cursor will move to the right, then the display will show:

0.00 mg/L Cl2

Note: *If Reagent Blank Correction is on, the display may flash "limit". See Section 1.*

6. Fill another cell with 10 mL of sample.

7. Add the contents of one DPD Free Chlorine Powder Pillow to the sample cell (the prepared sample). Cap the cell and swirl vigorously to dissolve the powder.

Note: *A pink color will develop if free chlorine is present.*

8. Immediately place the prepared sample into the cell holder. Tightly cover the sample cell with the instrument cap.

Note: *Perform Step 9 within one minute of reagent addition.*

Residual chlorine (free)

9. Press: **READ**

The cursor will move to the right, then the result in mg/L chlorine will be displayed.

Note: *Standard Adjust may be performed using a prepared standard (see Section 1).*

Note: *If the sample temporarily turns yellow after reagent addition, or the display flashes "limit", it is due to high chlorine levels. Dilute a fresh sample and repeat the test. A slight loss of chlorine may occur during dilution. Multiply the result by the dilution factor; see Section 1. Or, use the High Range Free Chlorine test, program #8.*

Nitrogen (ammonia)

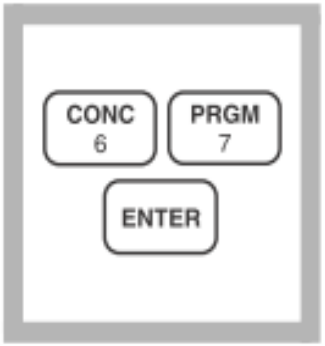
Salicylate Method

1. Enter the stored program number for nitrogen, ammonia, high range Test 'N Tube (NH_3-N) method.

Press: **PRGM**

The display will show:

PRGM ?



2. Press: **67 ENTER**

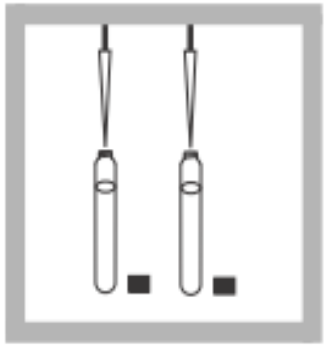
The display will show **mg/L, NH3-N** and the **ZERO** icon.

Note: *For alternate forms (NH_3), press the* **CONC** *key.*

Note: *For proof of accuracy, use a 10-mg/L nitrogen, ammonia standard in place of the sample.*

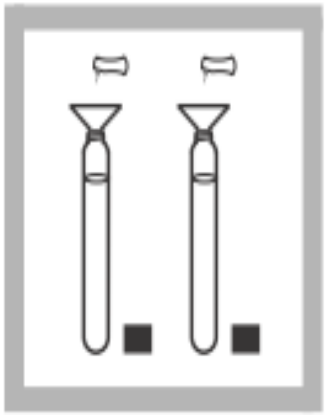
3. Insert the COD/TNT Adapter into the cell holder by rotating the adapter until it drops into place. Then push down to fully insert it.

Note: *For increased performance, a diffuser band covers the light path holes on the adapter. Do not remove the diffuser band.*

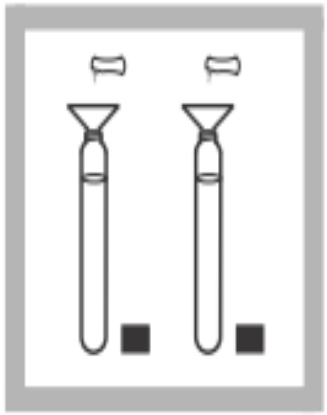


4. Remove the caps from 2 AmVer Diluent Reagent High Range Vials. Add 0.1 mL of sample to one vial (the sample). Add 0.1 mL of deionized water to the other (the blank).

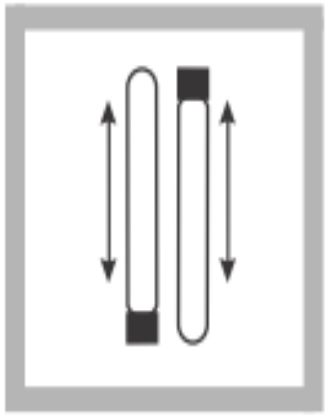
Nitrogen (ammonia)



5. Add the contents of 1 Ammonia Salicylate Reagent Powder Pillow for 5 mL Sample to each vial.

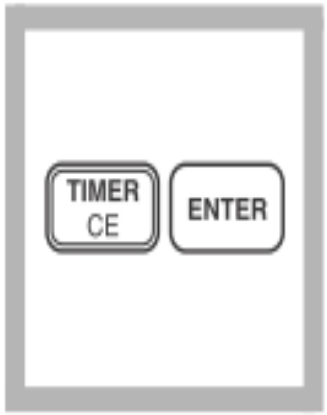


6. Add the contents of 1 Ammonia Cyanurate Reagent Powder Pillow for 5 mL Sample to each vial.



7. Cap the vials tightly and shake thoroughly to dissolve the powder.

Note: *A green color will develop if ammonia is present.*



8. Press:

TIMER ENTER

A 20-minute reaction period will begin.

Nitrogen (ammonia)

9. Clean the outside of the vial with a towel. After the timer beeps, place the blank into the vial adapter. Tightly cover the vial with the instrument cap.

Note: *Wipe with a damp cloth and follow with a dry one to remove fingerprints and other marks.*

10. Press: **ZERO**

The cursor will move to the right, then the display will show:

0 mg/L NH3-N

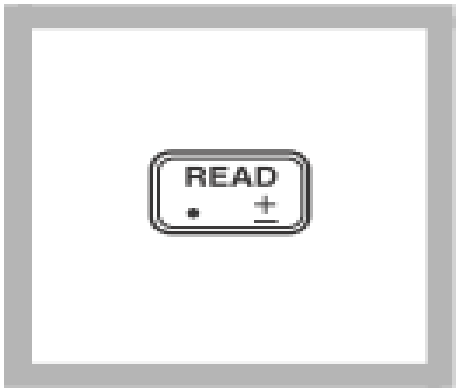
11. Place the prepared sample in the adapter.

Push straight down on the top of the vial until it seats solidly into the adapter.

Note: *Do not move the vial from side to side as this can cause errors.*

12. Tightly cover the vial with the instrument cap.

Nitrogen (ammonia)



13. Press: **READ**

The cursor will move to the right, then the result in mg/L NH_3-N will be displayed.

Note: *Standard Adjust may be performed using a prepared standard (see Standard Adjust in Section 1).*

Nitrogen (nitrates)

1. Enter the stored program number for high range nitrate nitrogen (NO_3^-–N) powder pillows.

Press: **PRGM**

The display will show:

PRGM ?

Note: *For most accurate results, perform a Reagent Blank Correction using deionized water (see Section 1).*

2. Press: **51 ENTER**

The display will show **mg/L, NO3-N** and the **ZERO** icon.

Note: *For alternate forms (NO_3), press the* **CONC** *key.*

3. Fill a sample cell with 10 mL of sample.

Note: *Adjust the pH of stored samples before analysis.*

4. Add the contents of one NitraVer 5 Nitrate Reagent Powder Pillow to the sample cell (the prepared sample). Cap the sample cell.

Note: *It is important to remove all of the powder from the foil pillow. Tap the pillow until no more powder pours out.*

Nitrogen (nitrates)

5. Press:
TIMER ENTER

A one-minute reaction period will begin. Shake the sample cell vigorously until the timer beeps.

Note: *It is important to shake the cell vigorously. Shaking time and technique influence color development. For most accurate results, do successive tests on a standard solution and adjust the shaking time to obtain the correct result.*

6. After the timer beeps, the display will show:
5:00 TIMER 2

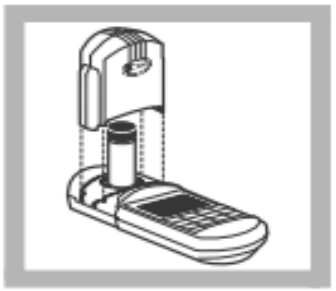
Press: **ENTER**

A five-minute reaction period will begin.

Note: *A deposit will remain after the reagent dissolves and will not affect test results.*

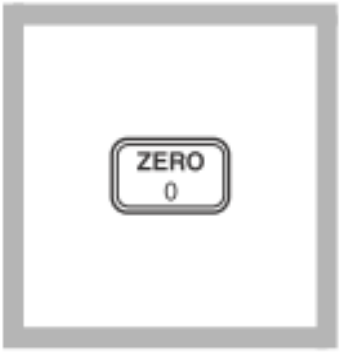
Note: *An amber color will develop if nitrate nitrogen is present.*

7. Fill another cell with 10 mL of sample (the blank). Wipe off any fingerprints or liquid.



8. Place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.

Nitrogen (nitrates)



9. When the timer beeps, press **ZERO.**

The cursor will move to the right, then the display will show:

0.0 mg/L NO3-N

Note: *If Reagent Blank Correction is on, the display may flash "limit". See Section 1.*

10. Place the prepared sample into the cell holder. Tightly cover the sample cell with the instrument cap.

11. Press: **READ**

The cursor will move to the right, then the result in mg/L NO_3-N (or alternate form) will be displayed.

Note: *Use of the Standard Adjust feature for each new lot of reagent is highly recommended. See* Accuracy Check.

Note: *Rinse the sample cell immediately after use to remove all cadmium particles. Save the spent sample for proper hazardous waste disposal for cadmium.*

Nitrogen (nitrites)

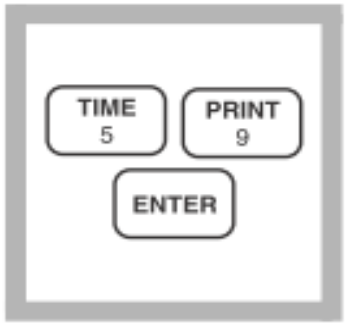
1. Enter the stored program number for high range nitrite (NO_2^-).

Press: **PRGM**

The display will show:

PRGM ?

Note: *For most accurate results, perform a Reagent Blank Correction using deionized water (see Section 1).*



2. Press: **59 ENTER**

The display will show **mg/L, NO2** and the **ZERO** icon.

Note: *For alternate forms (NO_2-N, $NaNO_2$), press the* **CONC** *key.*

3. Fill a sample cell with 10 mL of sample.

4. Add the contents of one NitriVer 2 Nitrite Reagent Powder Pillow. Cap the cell and invert 5-7 times to mix (the prepared sample).

Note: *A greenish-brown color will develop if nitrite is present.*

Note: *Avoid excessive mixing or low results may occur. Accuracy is not affected by undissolved powder.*

Nitrogen (nitrites)

5. Press:

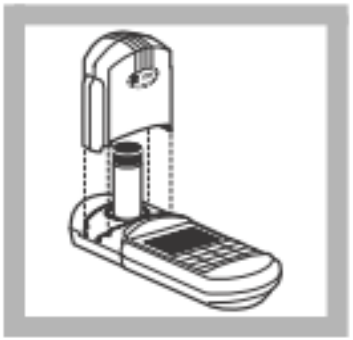
TIMER ENTER

A ten-minute reaction period will begin.

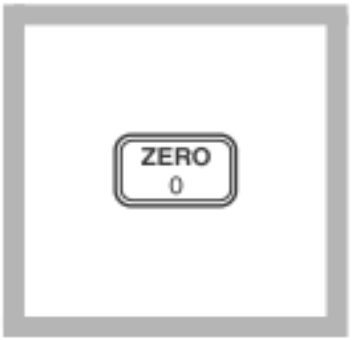
Do not move or disturb the sample cell during this reaction period.

6. Fill another sample cell with 10 mL of sample (the blank). Clean the outside of the cells with a towel.

Note: *Wiping with a damp towel, followed by a dry one, removes fingerprints and other marks.*



7. Place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.



8. Press: **ZERO**

The cursor will move to the right, then the display will show:

0 mg/L NO2

Note: *If Reagent Blank Correction is on, the display may flash "limit". See Section 1.*

Nitrogen (nitrites)

9. After the timer beeps, gently invert the prepared sample twice. Place the prepared sample into the cell holder. Tightly cover the sample cell with the instrument cap.

Note: *Avoid excessive mixing or low results may occur.*

10. Press: **READ**

The cursor will move to the right, then the result in mg/L nitrite will be displayed.

Note: *Standard Adjust may be performed using a prepared standard (see Standard Adjust in Section 1).*

Total Kjeldahl Nitrogen (TKN)

- Digestion: Sample + H_2SO_4 → $(NH_4)_2SO_4(aq)$ + $CO_2(g)$ + $SO_2(g)$ + $H_2O(g)$
- Liberation of ammonia and distillation: $(NH_4)_2SO_4(aq)$ + $2NaOH$ → $Na_2SO_4(aq)$ + $2H_2O(l)$ + $2NH_3(g)$
- Capture and collection of ammonia : HCl + NH_3 → ($NH_4^{(+)}$ + $Cl^{(-)}$) + $HCl_{(excess)}$ +H2O
- Back-titration: $HCl_{(excess)}$ + NaOH → NaCl+ H_2O

Total Kjeldahl Nitrogen (TKN)

Digestion → Distillation → Titration

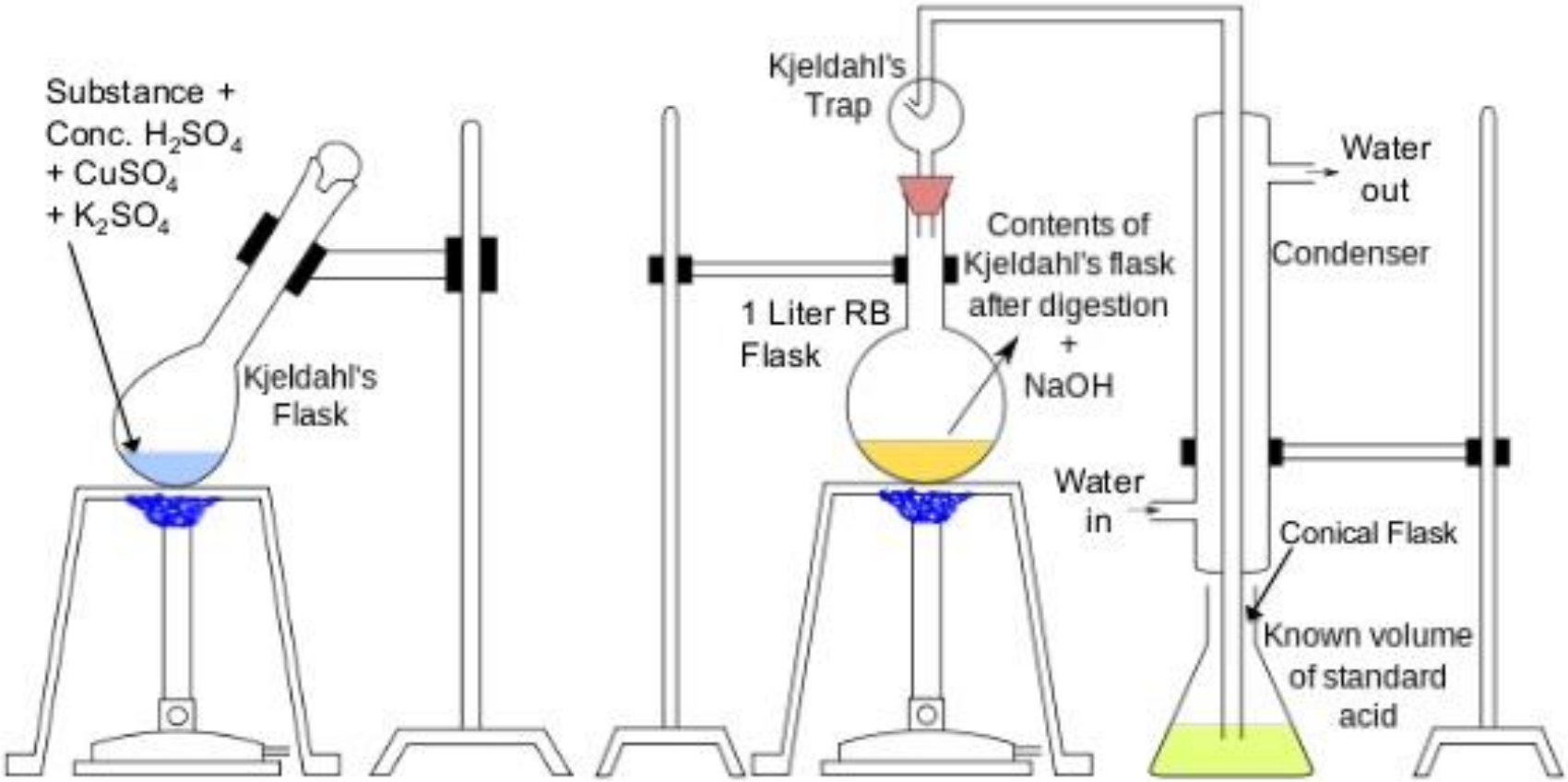


Image: Wikipedia

HOW TO MEASURE

1. adding an indicator dye to the acid/ammonia trapping solution. This dye should turn a strong color, indicating that a significant amount of the original trapping acid is still present.

2. putting a standard solution of NaOH (sodium hydroxide) into the buret (a long tube with a tap at the end), and slowly, slowly adding small amounts of the sodium hydroxide solution to the acid solution with the dye.

3. watching for the point at which the dye turns orange, indicating that the "endpoint" has been reached and that now all the acid has been neutralized by the base.

4. recording the volume of the neutralizing base (sodium hydroxide solution) that was necessary to reach the endoint.

5. performing a calculation to find the amount of ammonia, and thus nitrogen, that came from the original sample.

CALCULATIONS

CALCULATIONS

One mole of ammonia coming from the digestion mixture (and hence from the original protein) will neutralize exactly one mole of the acid in the trapping flask.

The first calculation, therefore, is to find the number of moles of ammonia that have been produced and then trapped from your sample(s).

This is done by,

- calculating the number of moles of acid in the trapping flask originally (before any ammonia was trapped) by multiplying the molarity of the acid solution by the volume of the trapping solution

moles of acid =
molarity of acid x volume used in flask
(molesA = M x V)

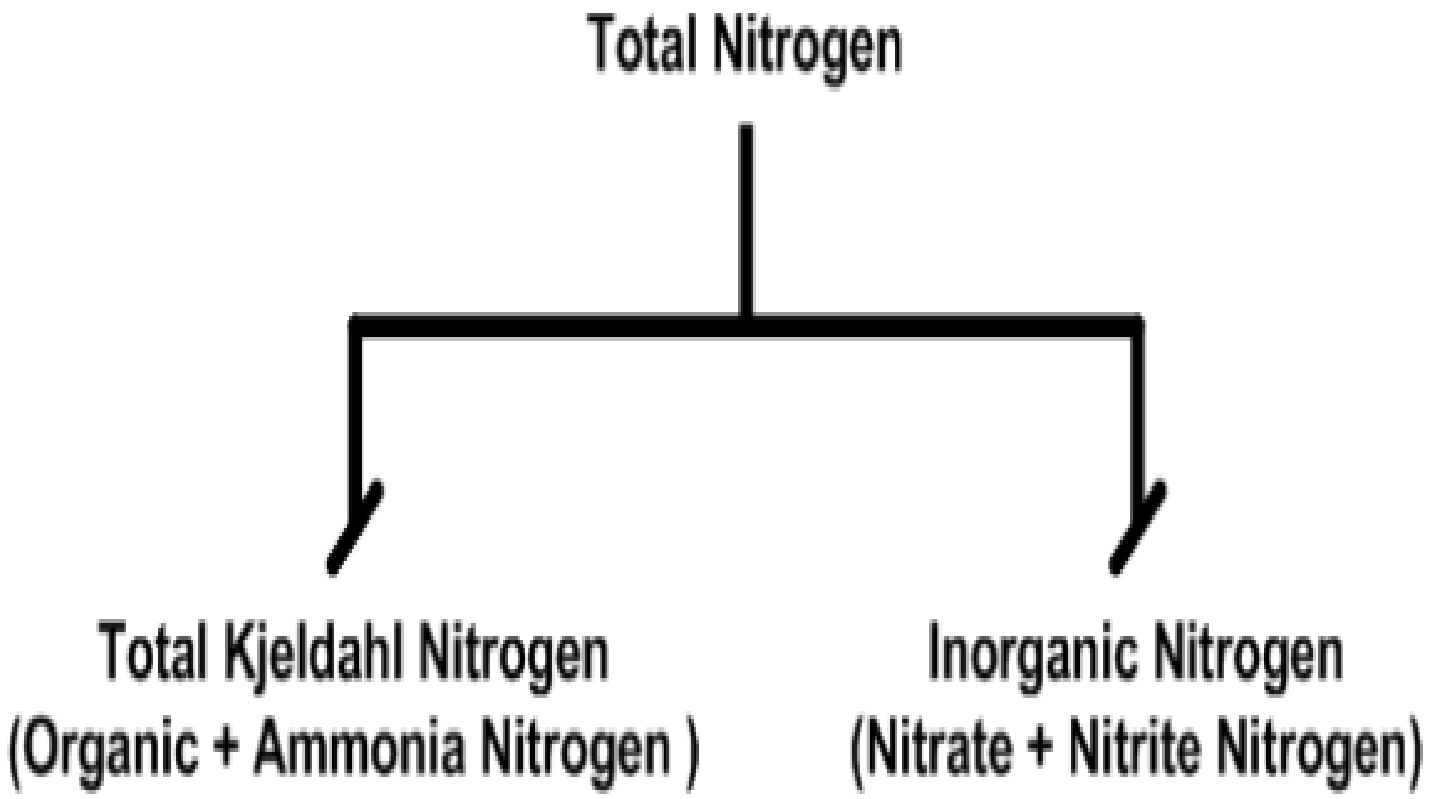
CALCULATIONS

- calculating the number of moles of base (NaOH) that were added from the buret to neutralize the remaining acid (that NOT neutralized by the ammonia).

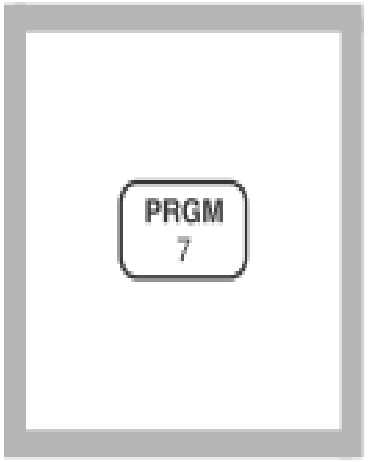
moles of base =
molarity of base x volume added from buret
(molesB = M x V)

- subtracting the "moles of base" added from the "moles of acid" present at the beginning, to get,
- the number of "moles of ammonia" coming from the protein,
- the number of "moles of ammonia" is the same as the "moles of nitrogen",

Total Kjeldahl Nitrogen (TKN)



Orthophosphate

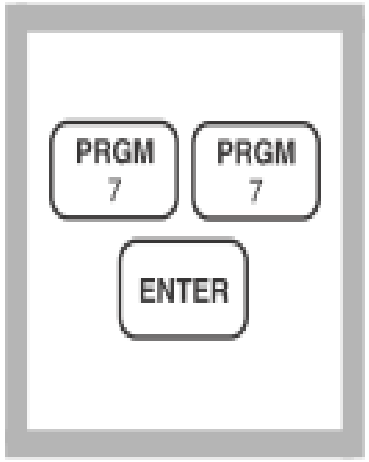


1. Enter the stored program number for high range phosphate (PO_4^{3-}) reagent solution.

Press: **PRGM**

The display will show:

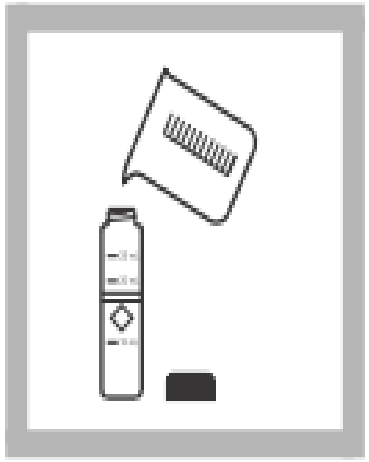
PRGM ?



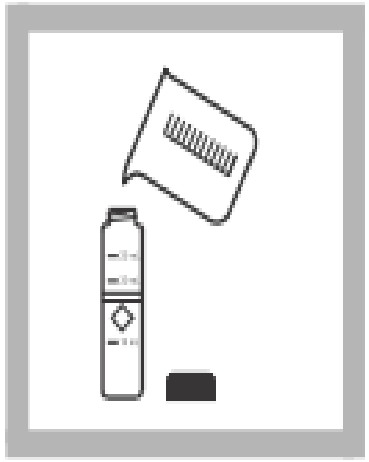
2. Press: **77 ENTER**

The display will show **mg/L, PO4** and the **ZERO** icon.

Note: *For alternate forms (P, P_2O_5), press the* **CONC** *key.*



3. Fill a sample cell with 25 mL of deionized water (the blank).



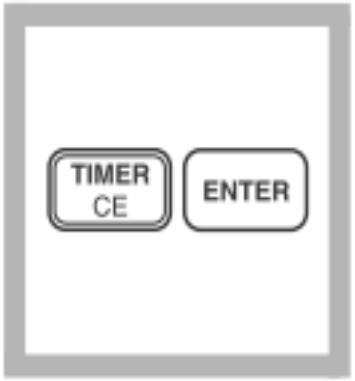
4. Fill another sample cell with 25 mL of sample (the prepared sample).

Note: *For best results, the sample temperature should be 20-25 °C.*

Orthophosphate

5. Add 1.0 mL of Molybdovanadate Reagent to each sample cell. Cap the cells and invert to mix.

Note: *A yellow color will form if phosphate is present. A small amount of yellow will be present in the blank, because of the reagent.*

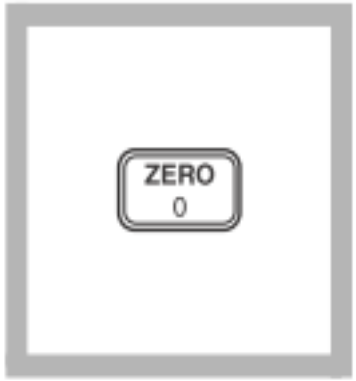


6. Press:

TIMER ENTER

A five-minute reaction period will begin.

7. After the timer beeps, place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.



8. Press: **ZERO**

The cursor will move to the right, then the display will show:

0.0 mg/L PO4

Orthophosphate

9. Place the prepared sample into the cell holder. Tightly cover the sample cell with the instrument cap.

10. Press: **READ**

The cursor will move to the right, then the result in mg/L phosphate (or alternate form) will be displayed.

Note: *Use of the Standard Adjust feature with each new lot of reagent is highly recommended. See Accuracy Check.*

ACID HYDROLYZABLE phosphate (meta, poly phosphate)

1. Measure 25 mL of sample into a 50-mL erlenmeyer flask using a graduated cylinder.

Note: *Wash all glassware with 6 N hydrochloric acid. Rinse with deionized water. Do not use detergents containing phosphate to clean glassware.*

2. Add 2.0 mL of 5.25 N Sulfuric Acid Solution.

Note: *Use the 1-mL calibrated dropper provided.*

3. Place the flask (the prepared sample) on a hot plate. Boil gently for 30 minutes.

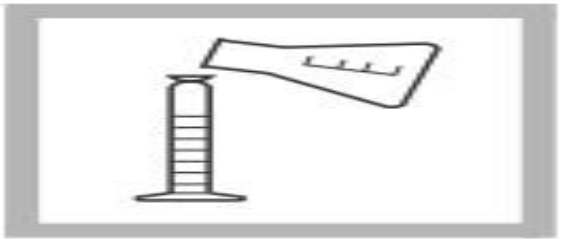
Note: *Samples should be concentrated to less than 20 mL for best recovery. After concentration, maintain the volume near 20 mL by adding small amounts of deionized water. Do not exceed 20 mL.*

4. Cool the hot prepared sample to room temperature.

ACID HYDROLYZABLE phosphate (meta, poly phosphate)

5. Add 2.0 mL of 5.0 N Sodium Hydroxide Solution to the prepared sample. Swirl to mix.

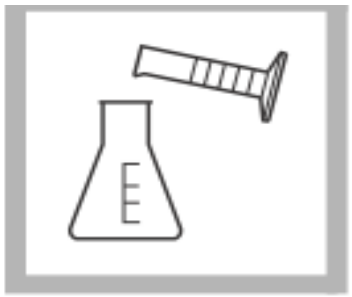
Note: *Use the 1-mL calibrated dropper provided.*



6. Pour the prepared sample into a graduated cylinder. Add deionized water rinsings from the flask to return the volume to 25 mL. Proceed with the appropriate reactive phosphorus test.

Note: *Results of the reactive phosphorus test at this point will include the orthophosphate plus the acid-hydrolyzable (condensed) phosphate. The condensed phosphate concentration is determined by subtracting the results of a reactive phosphorus test on an untreated sample from this result. Make sure both results are in the same chemical form and units.*

Total phosphate



1. Measure 25 mL of sample into a 50-mL erlenmeyer flask using a graduated cylinder.

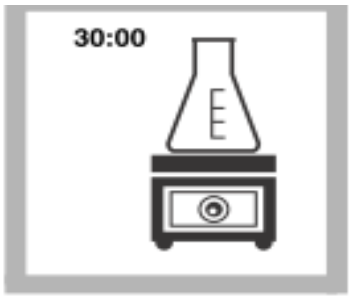
Note: *Rinse all glassware with 1:1 Hydrochloric Acid Solution. Rinse again with deionized water. Do not use detergents containing phosphates to clean glassware.*

Note: *Adjust the pH of stored samples before digestion.*

2. Add the contents of one Potassium Persulfate Powder Pillow. Swirl to mix.

3. Add 2.0 mL of 5.25 N Sulfuric Acid Solution.

Note: *Use the 1-mL calibrated dropper provided.*



4. Place the flask on a hot plate. Boil gently for 30 minutes.

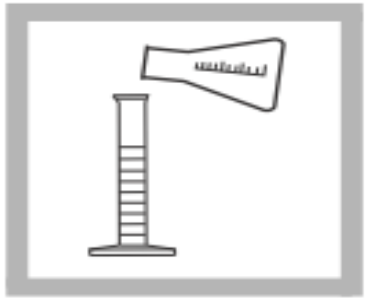
Note: *Samples should be concentrated to less than 20 mL for best recovery. After concentration, maintain the volume near 20 mL by adding small amounts of deionized water. Do not exceed 20 mL.*

Total phosphate

5. Cool the sample to room temperature.

6. Add 2.0 mL of 5.0 N Sodium Hydroxide Solution. Swirl to mix.

Note: *Use the 1-mL calibrated dropper provided.*



7. Pour the sample into a 25-mL graduated cylinder. Return the volume to 25 mL. Proceed with a reactive phosphorus test of the expected total phosphorus concentration range.

Note: *Use deionized water rinsings from the flask to adjust the volume.*

Note: *Results of the reactive phosphorus test at this point will include the organic phosphate plus the orthophosphate and the acid-hydrolyzable (condensed) phosphate. The organic phosphate concentration is determined by subtracting results of an acid hydrolyzable phosphorus test from this result. Make sure that both results are in the same units before taking the difference.*

Residual chlorine free

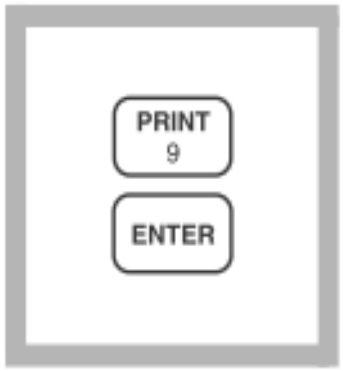
1. Enter the stored program number for free and total chlorine (Cl_2) powder pillows.

Press: **PRGM**

The display will show:

PRGM ?

Note: *For most accurate results, perform a Reagent Blank Correction using deionized water (see Section 1).*



2. Press: **9 ENTER**

The display will show **mg/L, Cl2** and the **ZERO** icon.

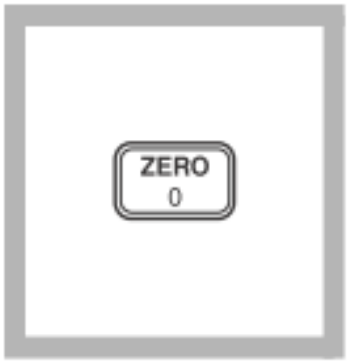
3. Fill a sample cell with 10 mL of sample (the blank).

Note: *Samples must be analyzed immediately and cannot be preserved for later analysis.*

Note: *The SwifTest Dispenser for Free Chlorine can be used in place of the powder pillows in step 7.*

4. Place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.

Residual chlorine free



5. Press: **ZERO**

The cursor will move to the right, then the display will show:

0.00 mg/L Cl2

Note: *If Reagent Blank Correction is on, the display may flash "limit". See Section 1.*

6. Fill another cell with 10 mL of sample.

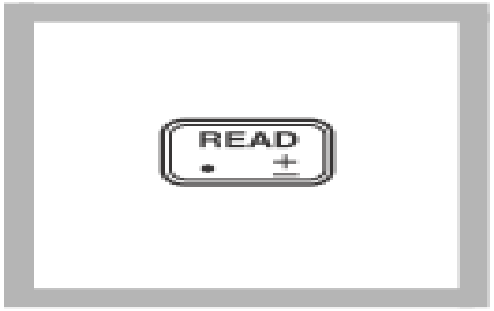
7. Add the contents of one DPD Free Chlorine Powder Pillow to the sample cell (the prepared sample). Cap the cell and swirl vigorously to dissolve the powder.

Note: *A pink color will develop if free chlorine is present.*

8. Immediately place the prepared sample into the cell holder. Tightly cover the sample cell with the instrument cap.

Note: *Perform Step 9 within one minute of reagent addition.*

Residual chlorine free



9. Press: **READ**

The cursor will move to the right, then the result in mg/L chlorine will be displayed.

Note: *Standard Adjust may be performed using a prepared standard (see Section 1).*

Note: *If the sample temporarily turns yellow after reagent addition, or the display flashes "limit", it is due to high chlorine levels. Dilute a fresh sample and repeat the test. A slight loss of chlorine may occur during dilution. Multiply the result by the dilution factor; see Section 1. Or, use the High Range Free Chlorine test, program #8.*

OZONE

Indigo Method (Using AccuVac Ampuls)

1. Enter the stored program number for Ozone (O_3) AccuVac ampuls.

Press: **PRGM**

The display will show:

PRGM ?

2. Press: **72 ENTER** for low range ozone

Press: **73 ENTER** for mid range ozone

Press: **74 ENTER** for high range ozone.

The display will show **mg/L, O3** and the **ZERO** icon.

3. Gently collect at least 40 mL of sample in a 50-mL beaker.

Note: *Samples must be analyzed immediately and cannot be preserved for later analysis. See* Sampling and Storage *following these steps for proper collection.*

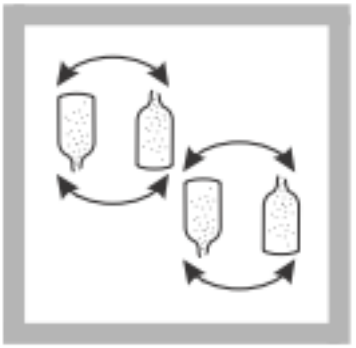
4. Collect at least 40 mL of ozone-free water (blank) in another 50-mL beaker.

Note: *Ozone-free water used for the blank may be deionized water or tap water.*

OZONE

5. Fill one Indigo Ozone Reagent AccuVac Ampul with the sample and one ampul with the blank.

Note: *Keep the tip immersed while the ampul fills.*



6. Quickly invert both ampuls several times to mix. Wipe off any liquid or fingerprints.

Note: *Part of the blue color will be bleached if ozone is present. (The sample will be lighter than the blank.)*

7. Place the **sample** AccuVac ampul into the cell holder. Tightly cover the ampul with the instrument cap.

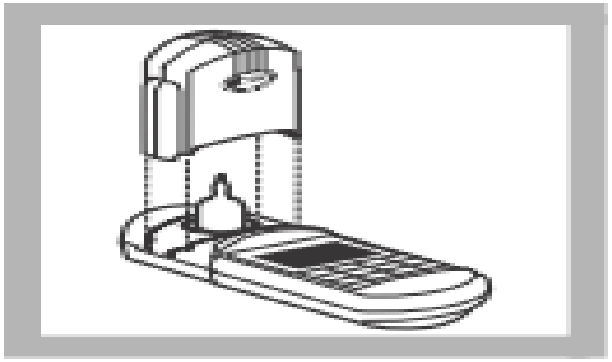
Note: *Standardization for this procedure is intentionally reversed.*

8. Press: **ZERO**

The cursor will move to the right, then the display will show:

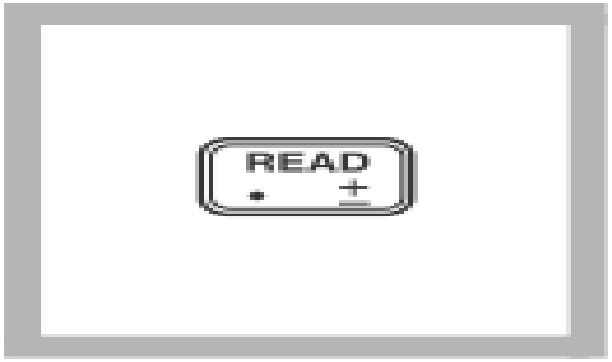
0.00 mg/L O3

OZONE



9. Place the AccuVac ampul containing the **blank** into the cell holder. Tightly cover the ampul with the instrument cap.

Note: *Standardization for this procedure is intentionally reversed.*



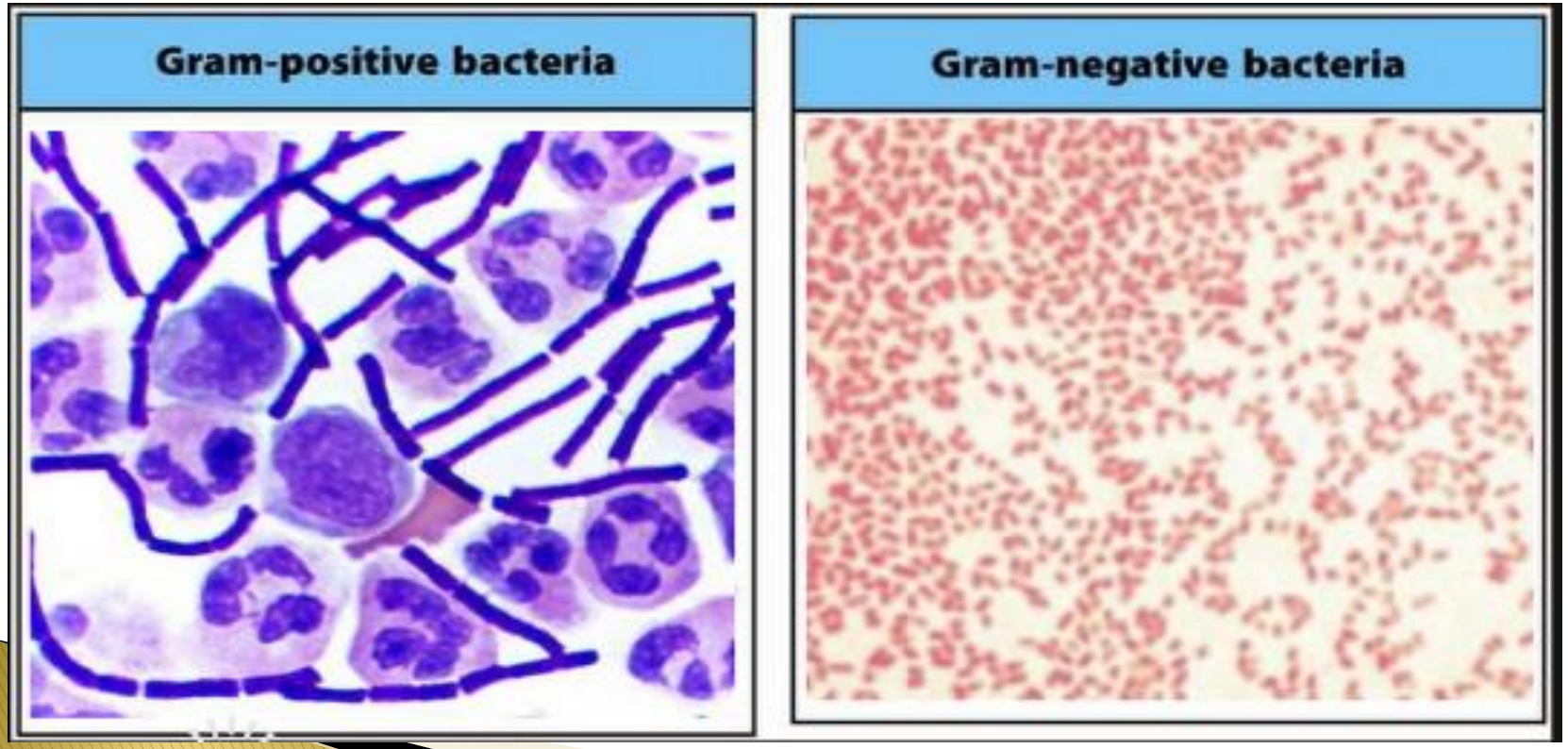
10. Press: **READ**

The cursor will move to the right, then the result in mg/L ozone will be displayed.

Note: *Standard Adjust may be performed using a prepared standard (see Section 1).*

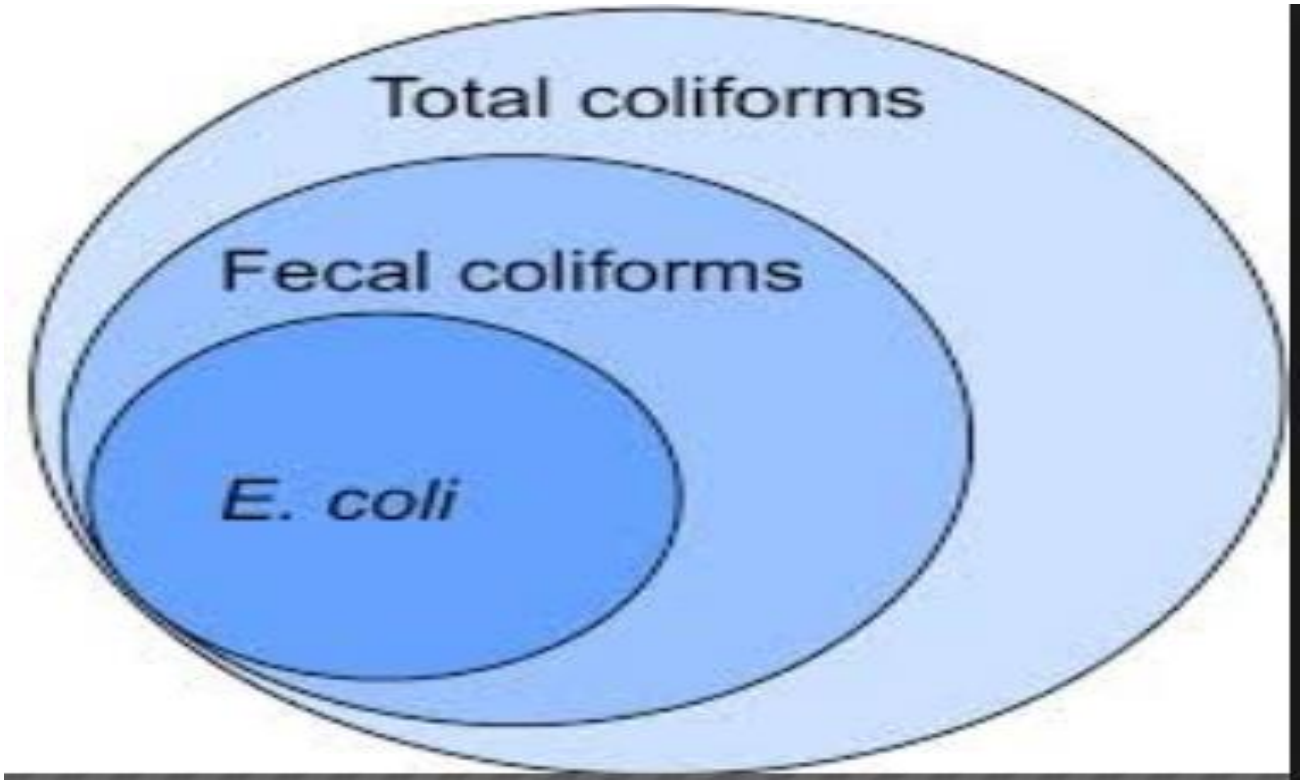
BACTERIA (GRAM STAIN CLASSIFICATION)

- This stain will either stain the cells purple (for positive) or pink (for negative).

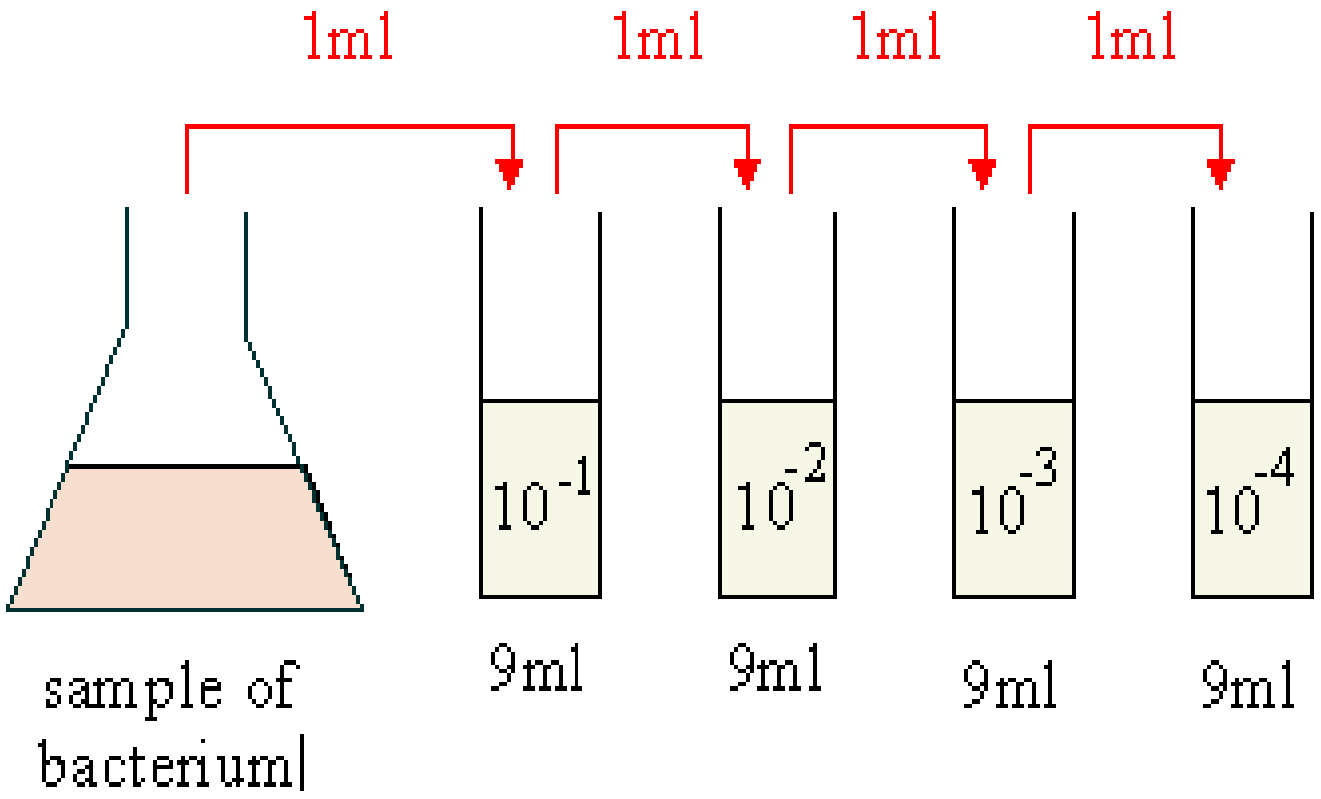


Coliforms

- Gram negative bactria



Serial dilution



Media

Table A5.1 Culture media for MPN[a]

Medium	Uses	Incubator temperature	Remarks
MacConkey broth	Presumptive isolation of coliform bacteria	35 ± 0.5 °C or 37 ± 0.5 °C	Traditional medium for the presumptive isolation of coliform bacteria by MPN. The quality of bile salts can vary and may affect the result
Lauryl tryptose (lactose) broth	Presumptive isolation of coliform bacteria	35 ± 0.5 °C or 37 ± 0.5 °C	—
	Confirmation of thermotolerant coliform bacteria	44 °C	—
Improved formate lactose glutamate medium	Presumptive isolation of coliform bacteria	35 ± 0.5 °C or 37 ± 0.5 °C	This is a selective medium because it contains chemically defined nutrients that can be utilized only by a limited number of bacterial species. The composition of the medium is complex and special care is required during preparation
Brilliant green lactose (bile) broth; EC	Confirmation of coliform bacteria	35 ± 0.5 °C or 37 ± 0.5 °C	Media for gas production
	Confirmation of thermotolerant coliform bacteria	44 °C	
Tryptone water	Production of indole for confirmation of *Escherichia coli*	44 °C	The formation of indole, detected by the addition of Kovacs reagent[b] to tryptone water after incubation, with gas production from lactose at 44 °C indicates the presence of *E. coli*

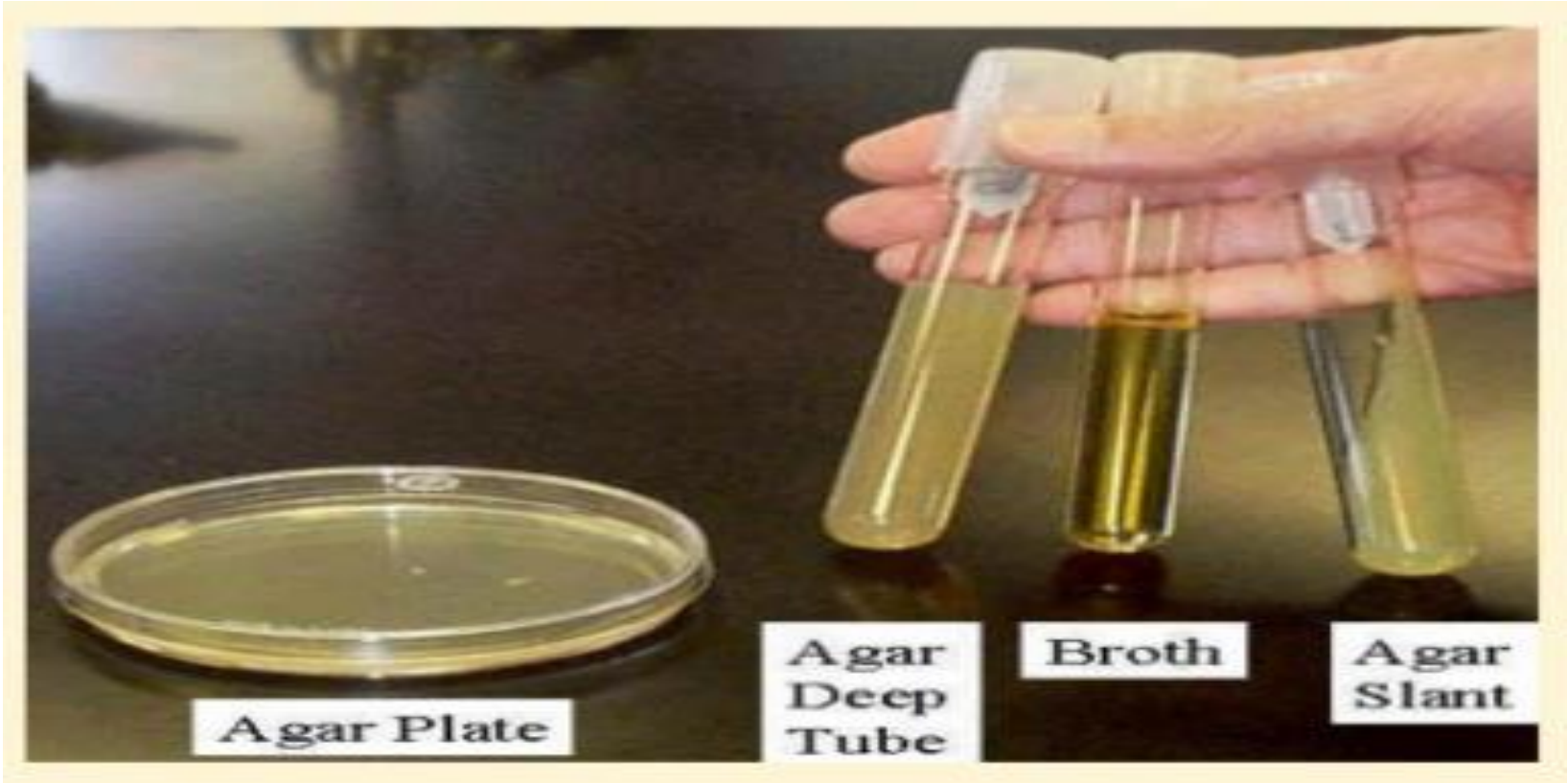
Double strength VS Single strength

Double strength Broth are used in some tubes of the MPN series, as large water samples may require this to minimize the final volume. This is because of the double strength broth has a stronger concentration compared to single strength broth. When 10mL of the sample is inoculated in 10mL of single strength broth, the media ingredient will get diluted to half, which may not support a positive growth of the organisms that may give inaccurate results. Hence, adding 10mL sample to 10mL of double strength medium will give a single strength medium. On the other hand, in two series of MPN method, where 1mL or 0.1 mL of sample is added will not dilute the final broth to much extent. These are the reasons why inoculating 10mL of sample double strength media is used.

Agar Vs Broth

- culture media are prepared in a liquid called a broth or a semi-solid or solid form called agar.
- If the tube is placed at an angle for the agar to solidify it is called a slant. If it is
- allowed to solidify straight up with the agar at the bottom of the test tube it is called an
- agar deep.

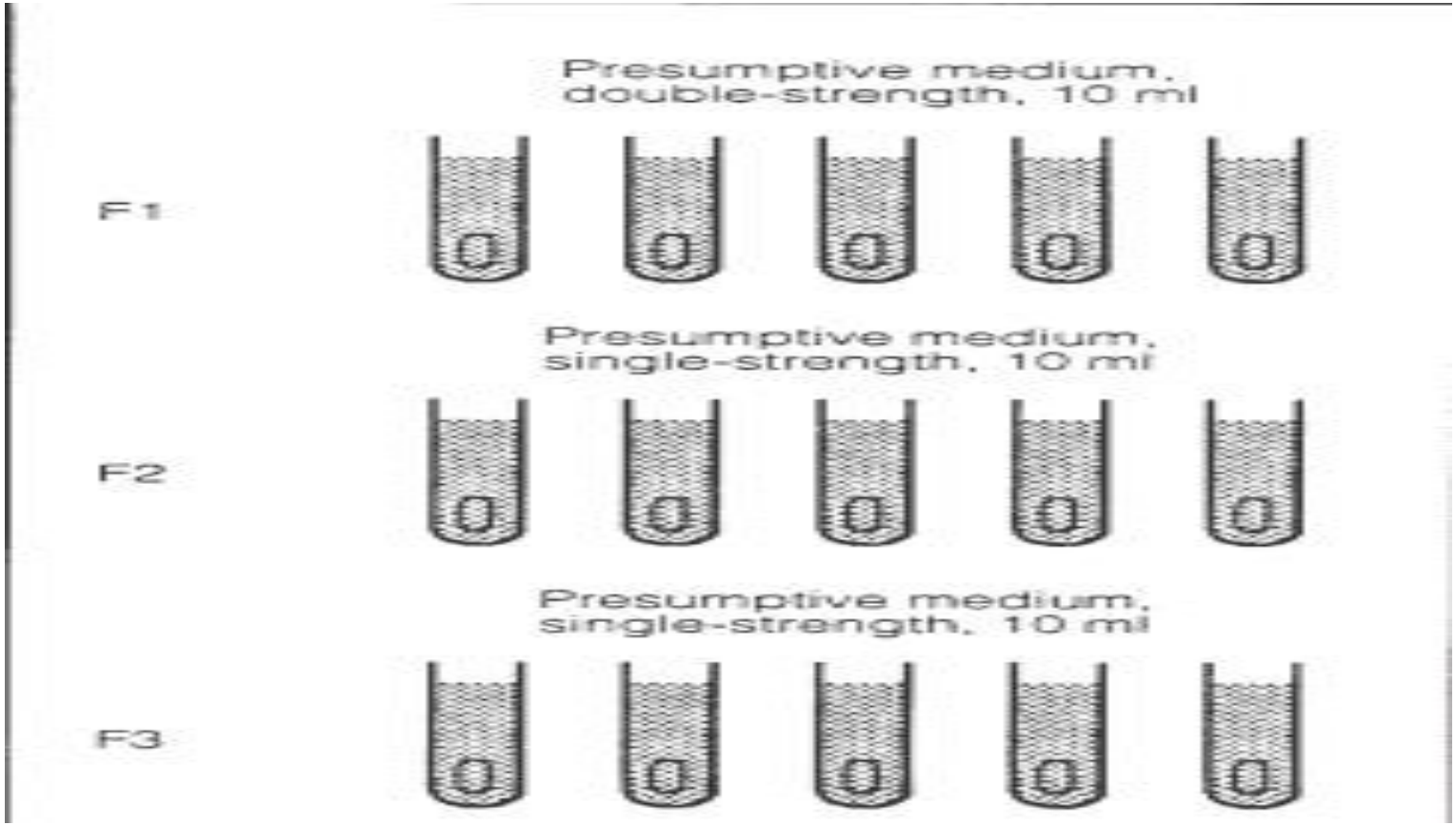
Media



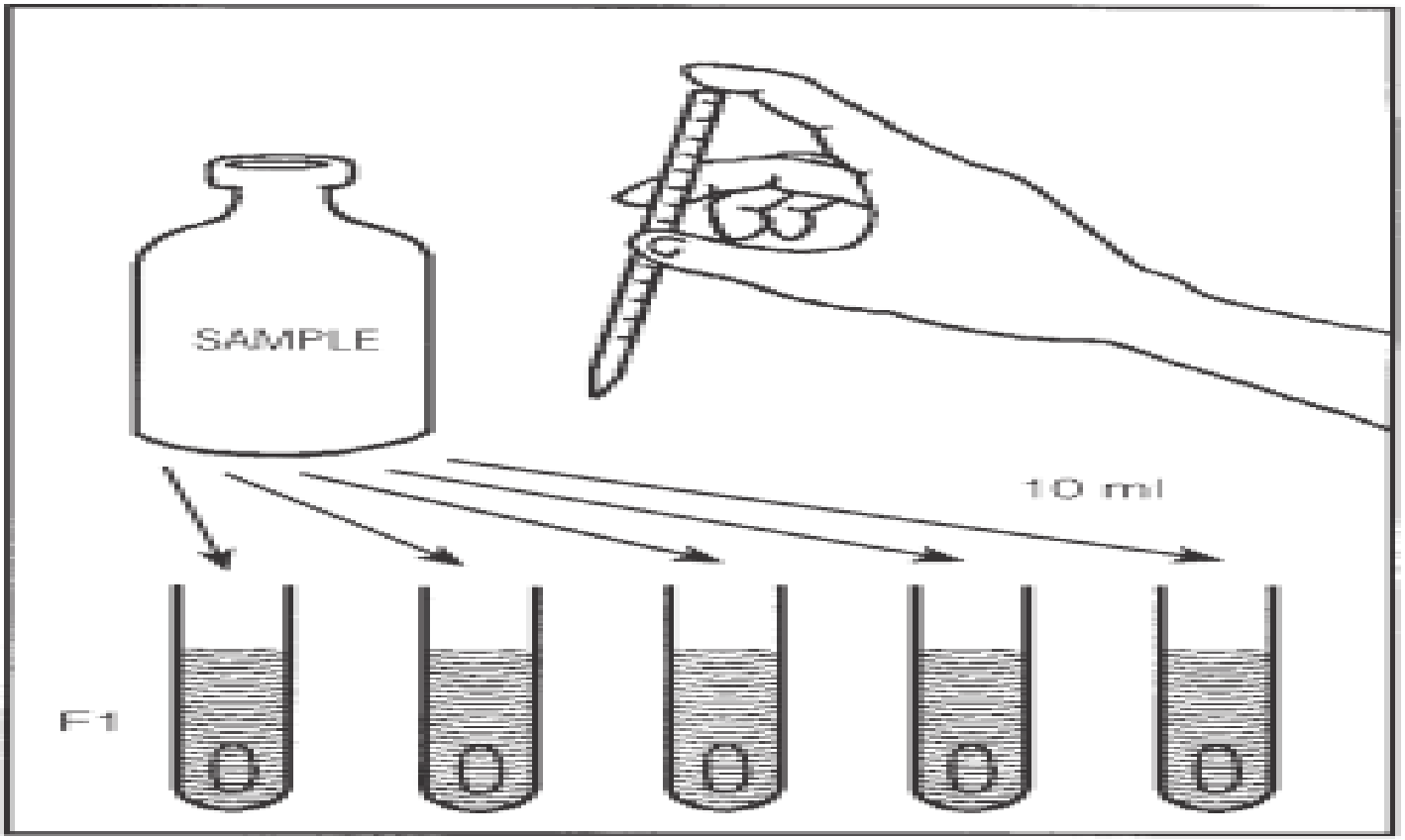
Most probable number (MPN)

- Presumptive test
- Confirmatory test
- Completed test

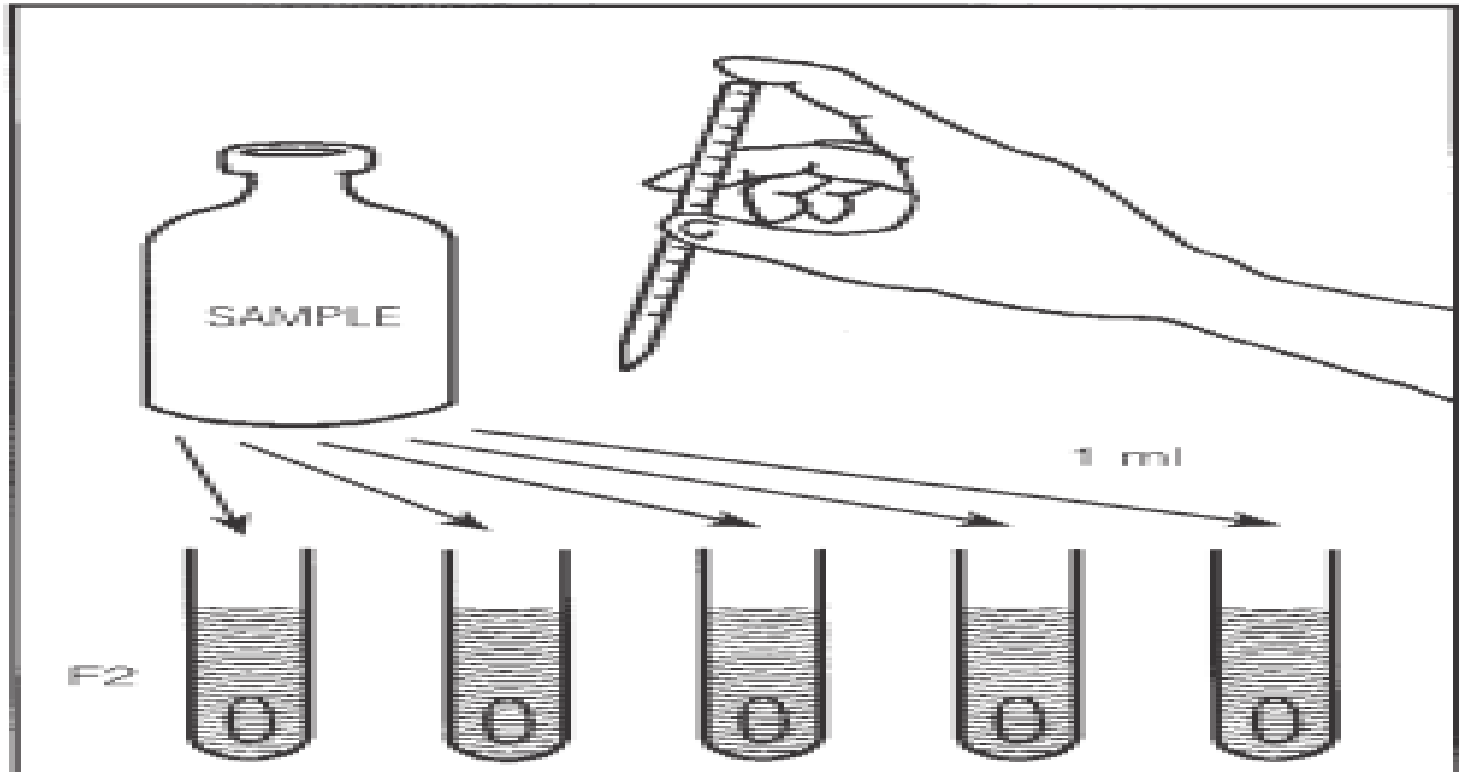
Presumptive test



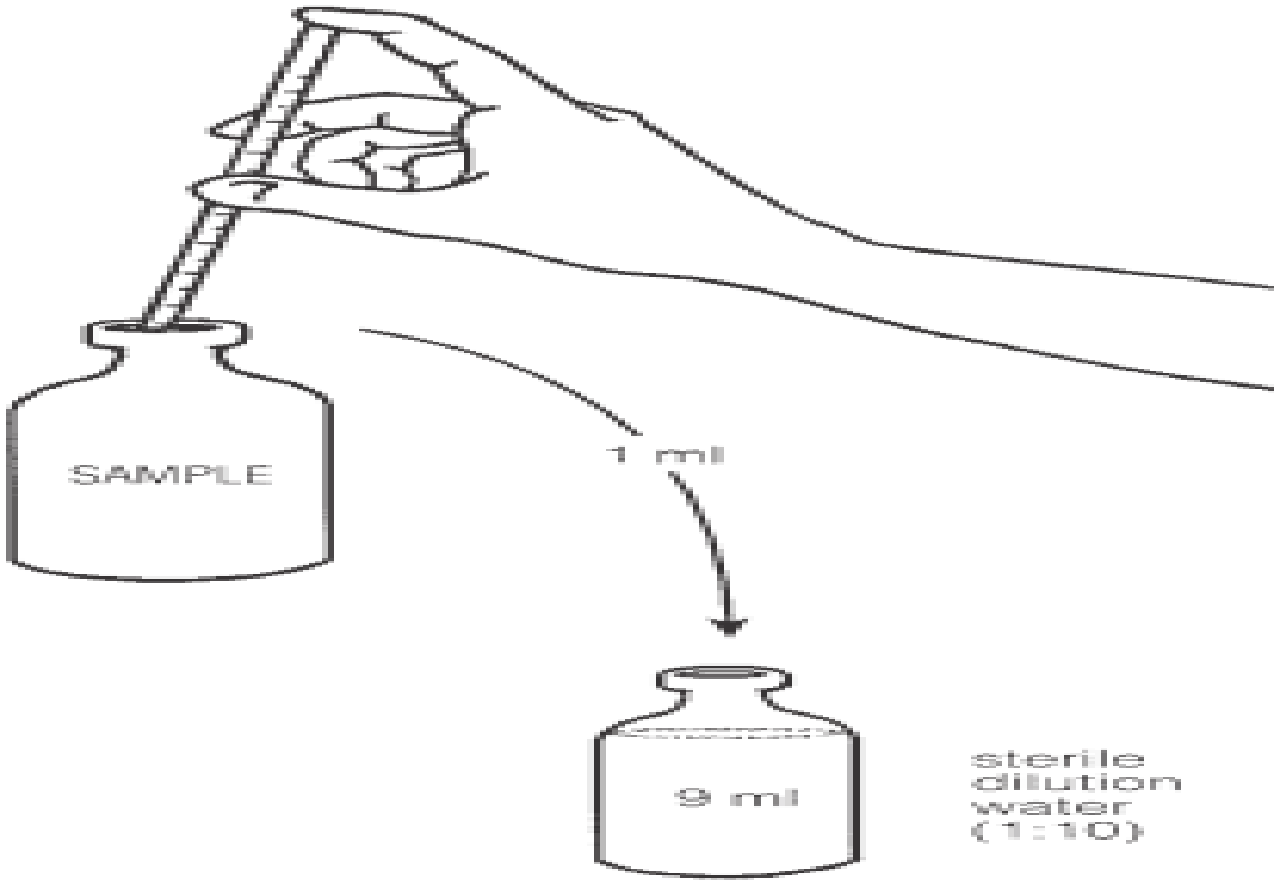
Presumptive test



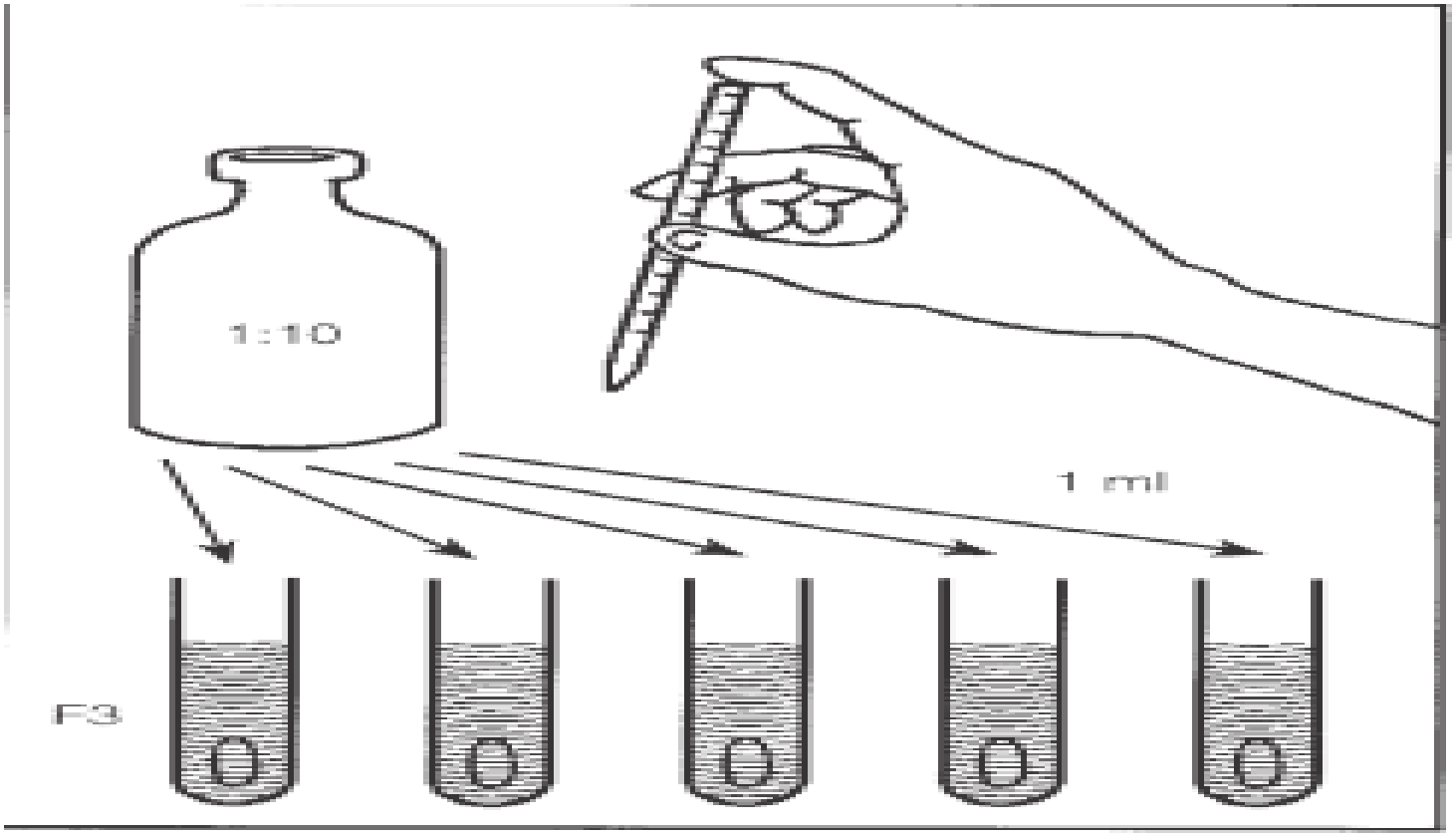
Presumptive test



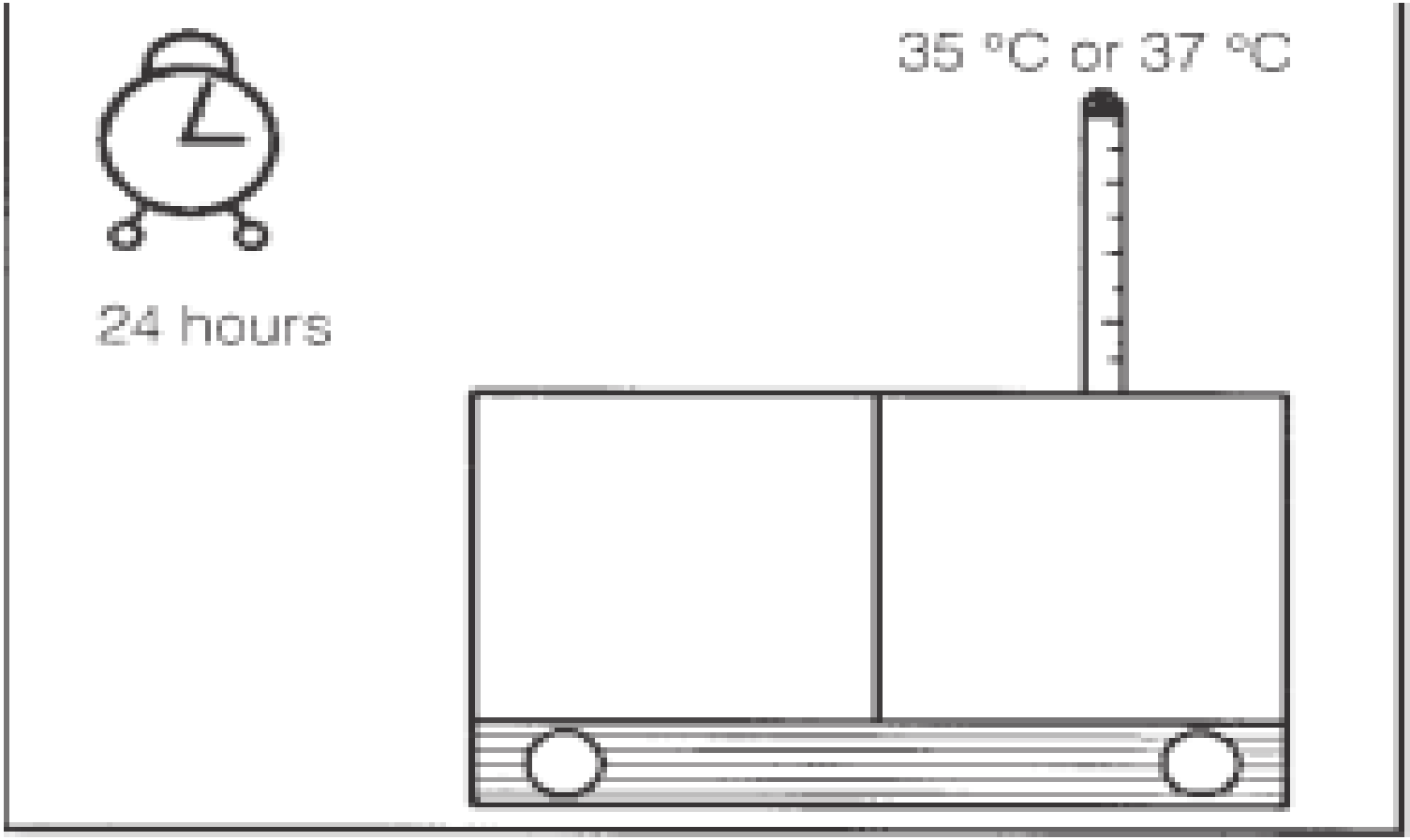
Presumptive test



Presumptive test



Presumptive test



How to calculate MPN

Table A5.3 MPN values per 100 ml of sample and 95% confidence limits for various combinations of positive and negative results (when five 10-ml, five 1-ml and five 0.1 ml test portions are used)

No. of tubes giving a positive reaction :			MPN (per 100 ml)	95% confidence limits	
5 of 10 ml	5 of 1 ml	5 of 0.1 ml		Lower	Upper
0	0	0	<2	<1	7
0	1	0	2	<1	7
0	2	0	4	<1	11
1	0	0	2	<1	7
1	0	1	4	<1	11
1	1	0	4	<1	11
1	1	1	6	<1	15
2	0	0	5	<1	13
2	0	1	7	1	17
2	1	0	7	1	17
2	1	1	9	2	21
2	2	0	9	2	21
2	3	0	12	3	28
3	0	0	8	1	19
3	0	1	11	2	25
3	1	0	11	2	25

Ambush (5,5,5)

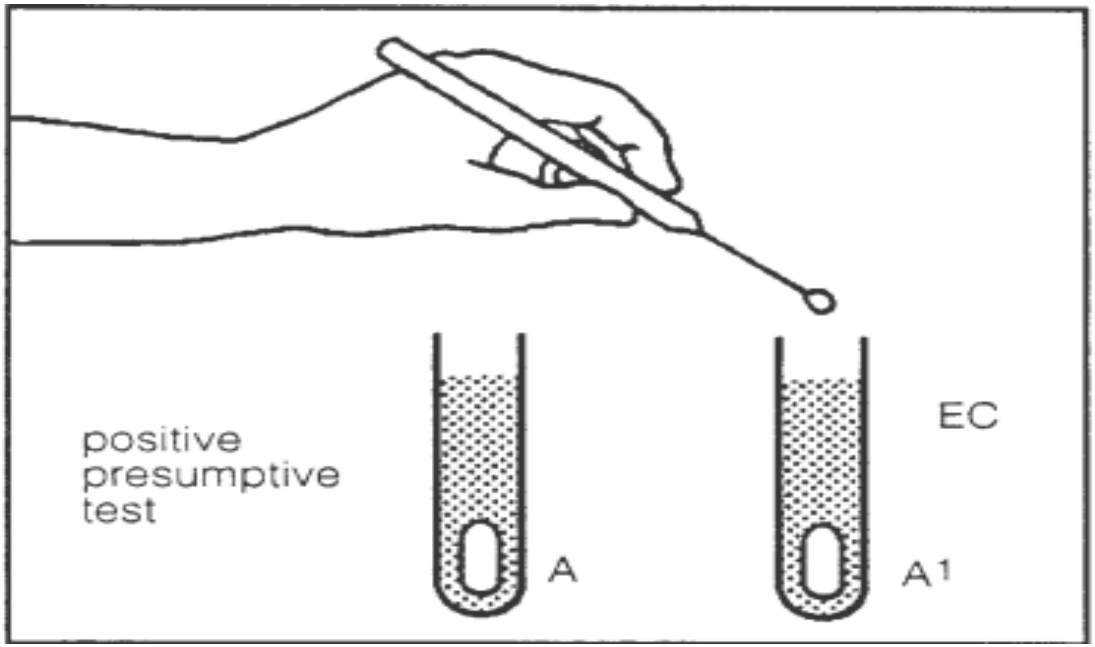
- More dilution required

Table A5.4 Example of multiplying factors for determination of the MPN for different dilutions of sample

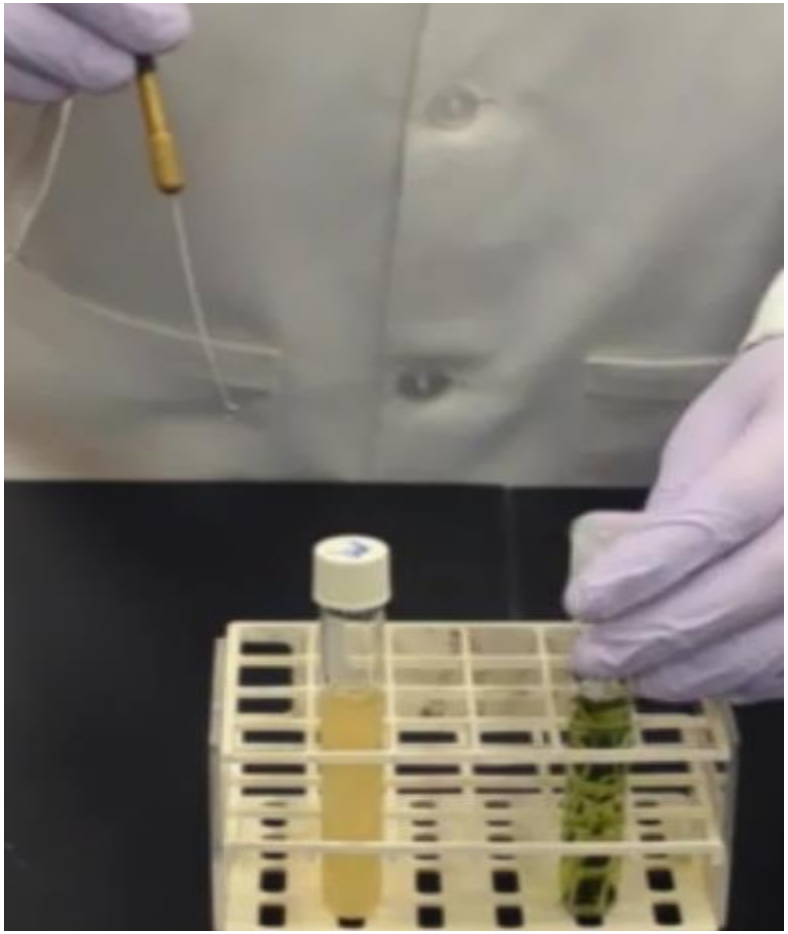
Example	No. of tubes giving a positive reaction					Coded result chosen	Multiplying factor for MPN
	5 of 1 ml	5 of 0.1 ml	5 of 0.01 ml	5 of 0.001 ml	5 of 0.0001 ml		
1	5	5	2	0	0	5–2–0	100
2	5	5	4	1	0	5–4–1	100
3	5	3	0	0	0	5–3–0	10
4	5	5	5	3	1	5–3–1	1000
5	0	1	0	0	0	0–1–0	10

Confirmatory test

- Confirm the presumptive results after 24 and 48 hours by transferring a loopful broth to a confirmatory broth and incubating at 44°C for 24 hours.



Take a loop



Confirmatory test

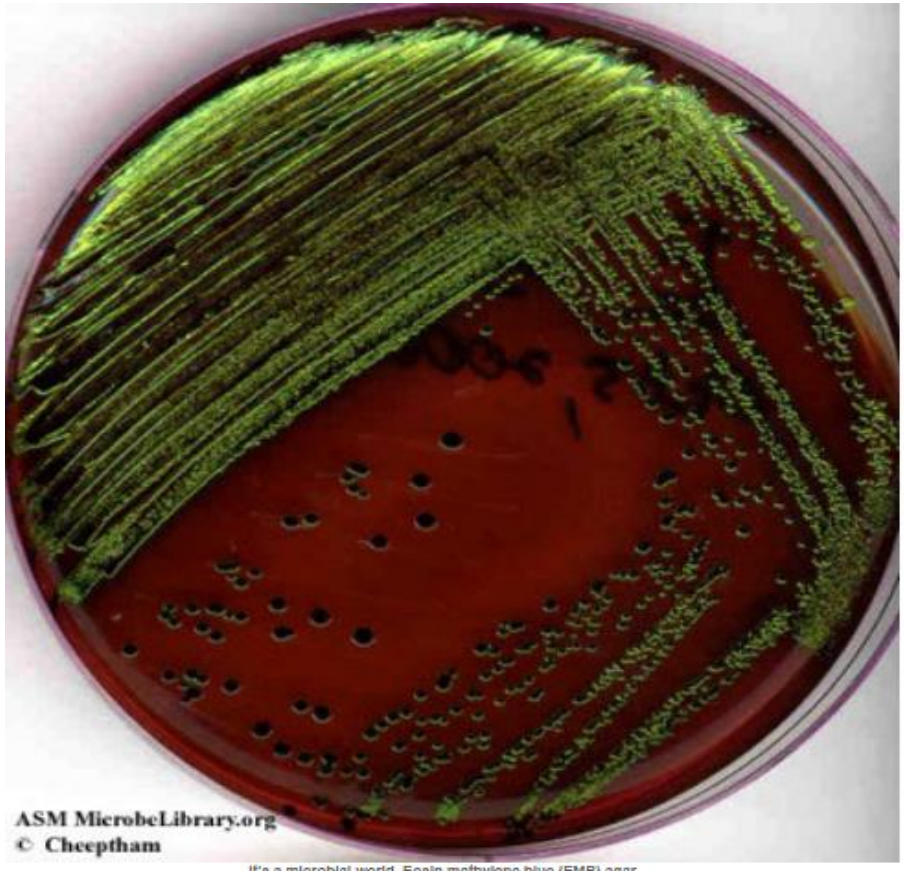
- The presence of thermotolerant coliforms (E. Coli) is confirmed if gas is present in the confirmatory broth after 24 hours at 44°C. Determine the MPN from the Table as before.

Completed test

- Since some of the positive results from the confirmatory test may be false, it is desirable to do completed tests. For this inoculum from each positive tube of the confirmatory test is streaked on a plate of EMB (Eosin Methylene Blue) or Endo agar.

E Coli On EMB Agar

greenish metallic sheen



Membrane filtration technique (MF)

- The choice of the volume of sample to be filtered will depend on the type of water. Examples of typical volumes are provided in the next Table

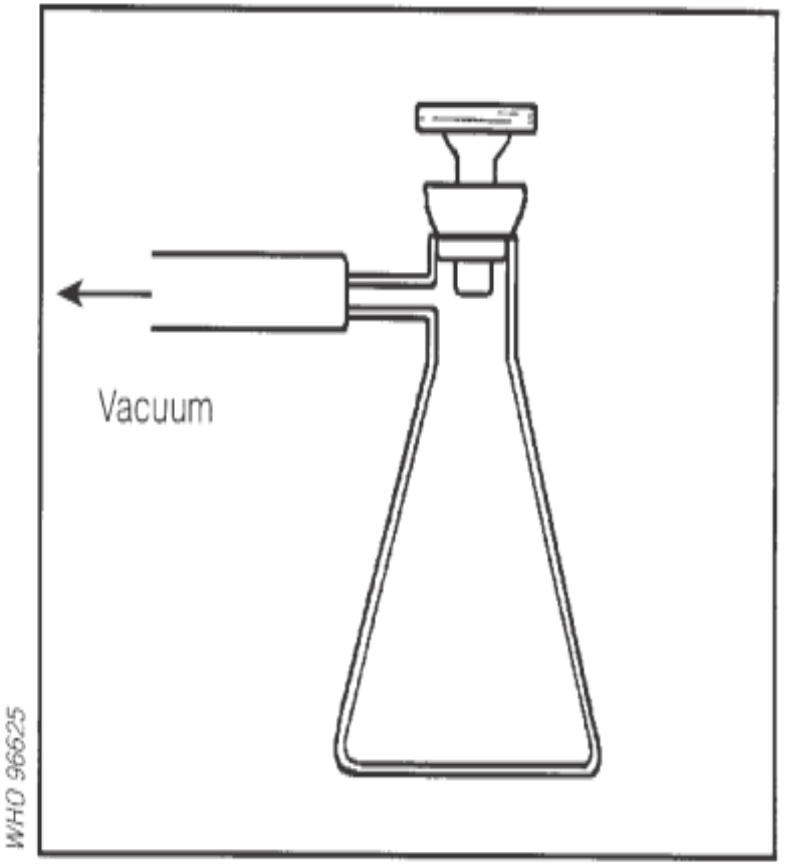
Table 4.3 Typical sample volumes for membrane-filtration analysis

Sample type	Sample volume (ml)
Treated drinking-water	100
Partially treated drinking-water	10–100
Protected source water or groundwater	10–100
Surface water and water from open wells	0.1–100[a]

[a] Volumes less than 10 ml should be added to the filtration apparatus after addition of at least 10 ml of sterile diluent to ensure adequate dispersal across the surface of the membrane filter.

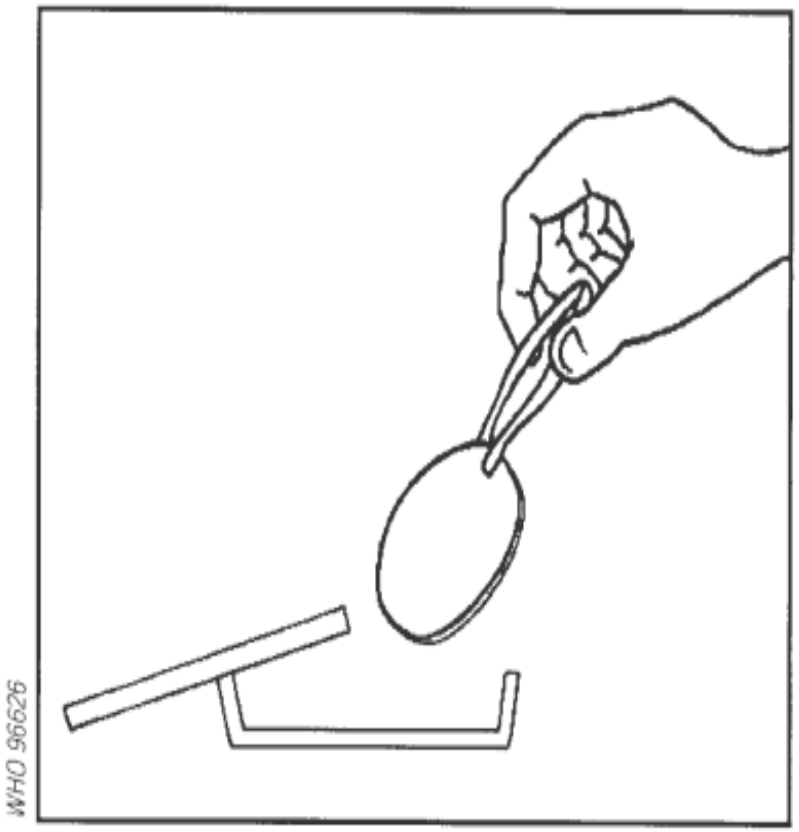
Procedure

A. Connect the Erlenmeyer (side-arm) flask to the vacuum source (turned off) and place the porous support in position. If an electric pump is used, it is advisable to put a second flask between the Erlenmeyer flask and the vacuum source; this second flask acts as a water trap, and thus protects the electric pump.



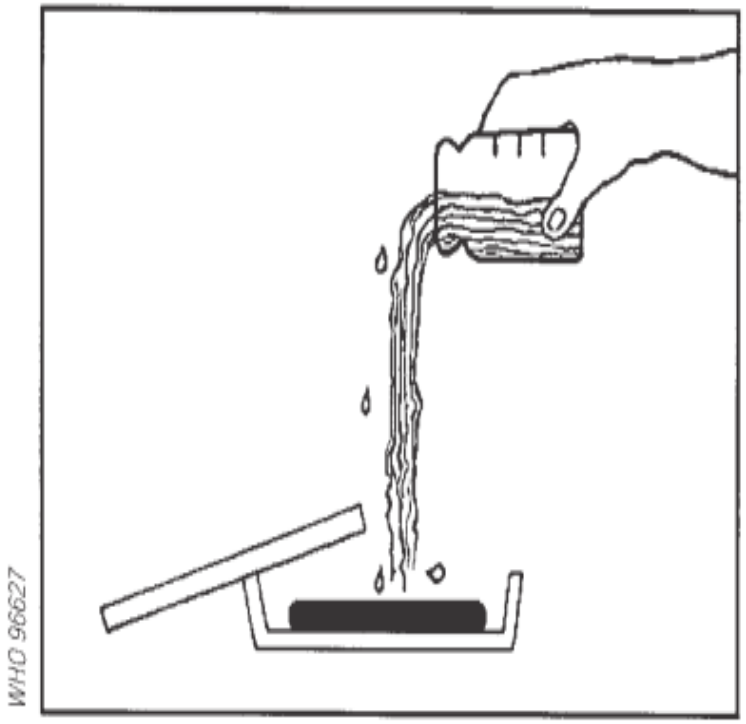
Procedure

B. Open a sterile Petri dish and place a sterile absorbent pad in it.



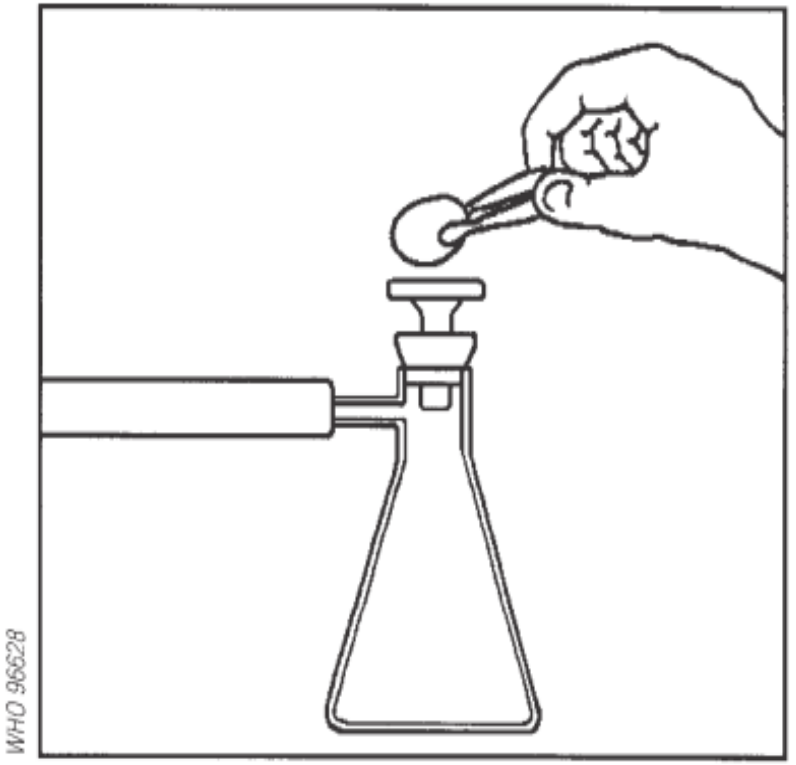
Procedure

C. Add broth medium to saturate the pad; remove excess broth.



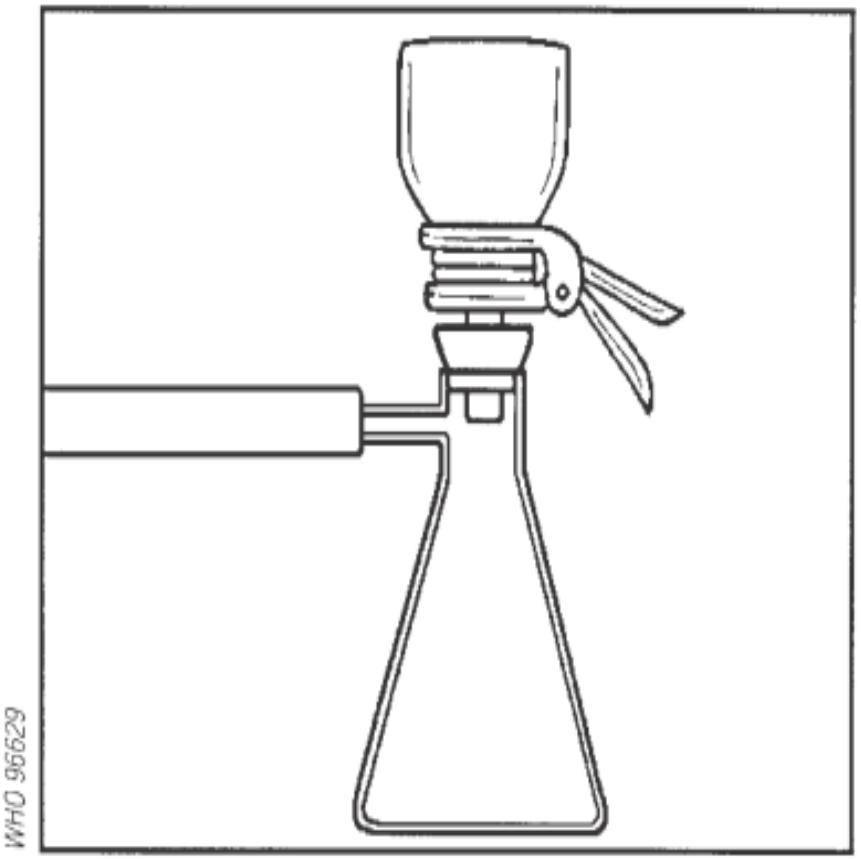
Procedure

D. Assemble the filtration unit by placing a sterile membrane filter on the porous support, using forceps sterilized by flaming.



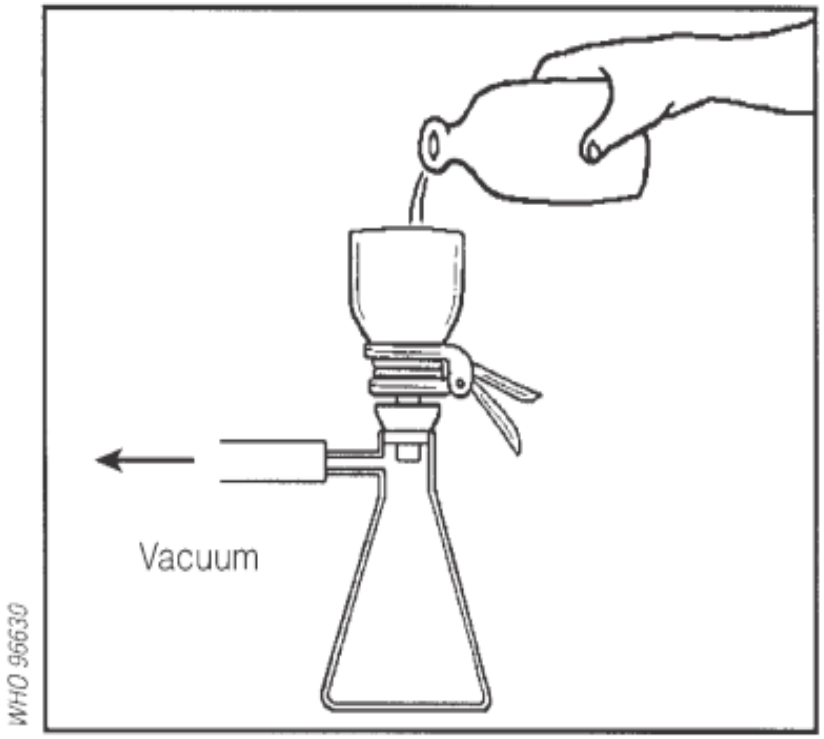
Procedure

E. Place the upper container in position and secure it. (The type of clamp used will depend on the type of equipment.)



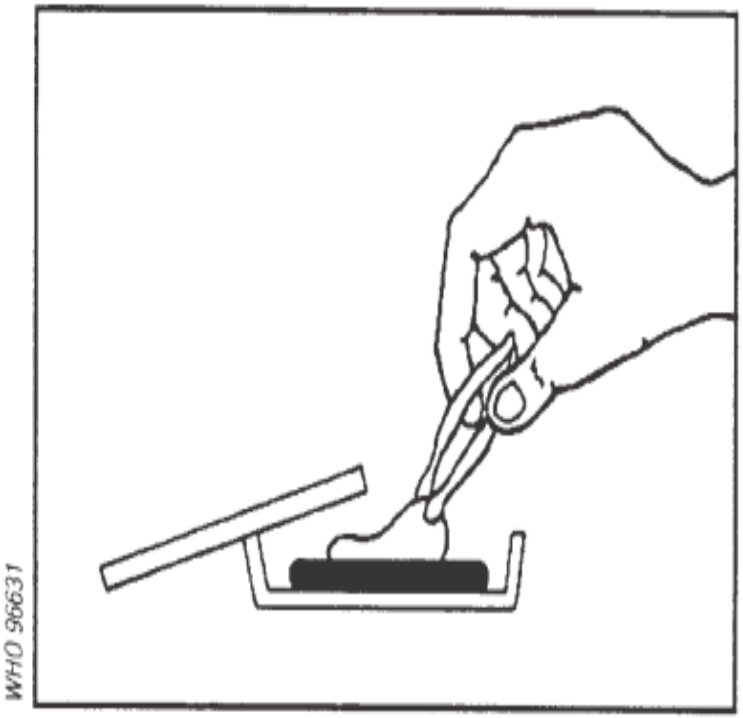
Procedure

F. Pour the volume of sample chosen as optimal for the type of water (see Table 4.3, p. 61), into the upper container. If the test sample is less than 10 ml, at least 20 ml of sterile dilution water should be added to the top container before filtration. Apply the vacuum.



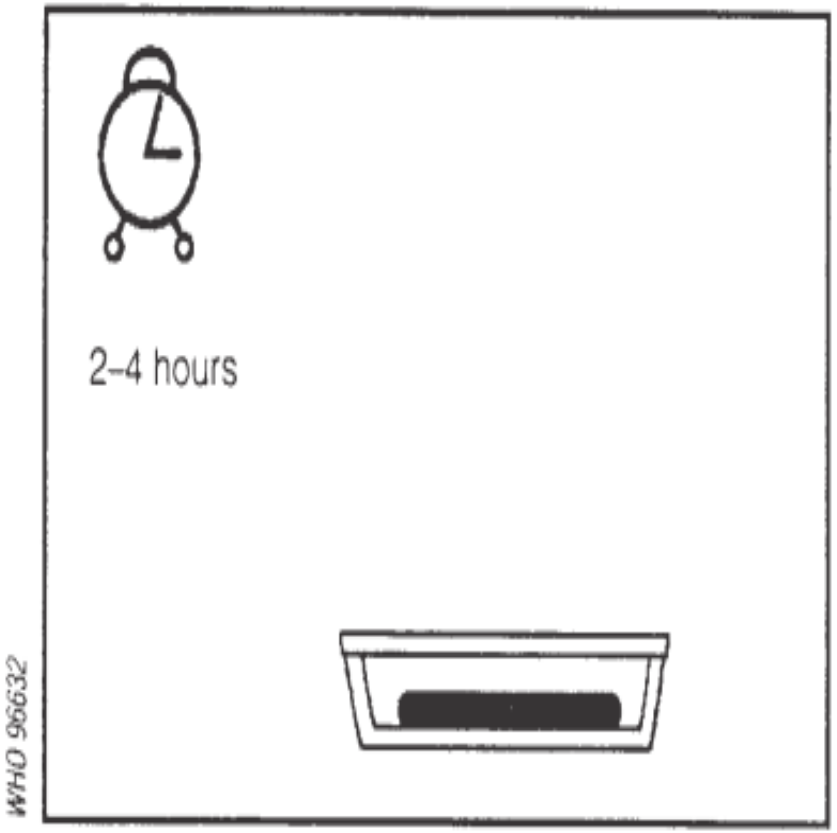
Procedure

G. Take the filtration unit apart and, using the sterile forceps, place the membrane filter in the Petri dish on the pad with the grid side up. Make sure that no air bubbles are trapped between the pad and the filter.



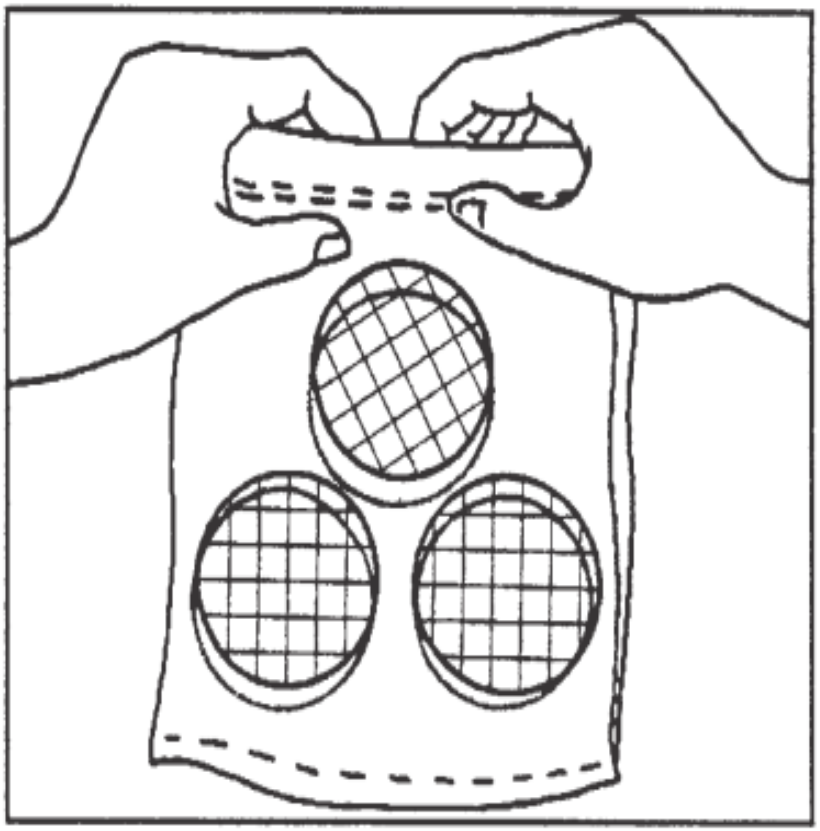
Procedure

H. Leave the Petri dish at room temperature or at 35 or 37 °C for 2–4 hours, for resuscitation of stressed microbes.



Procedure

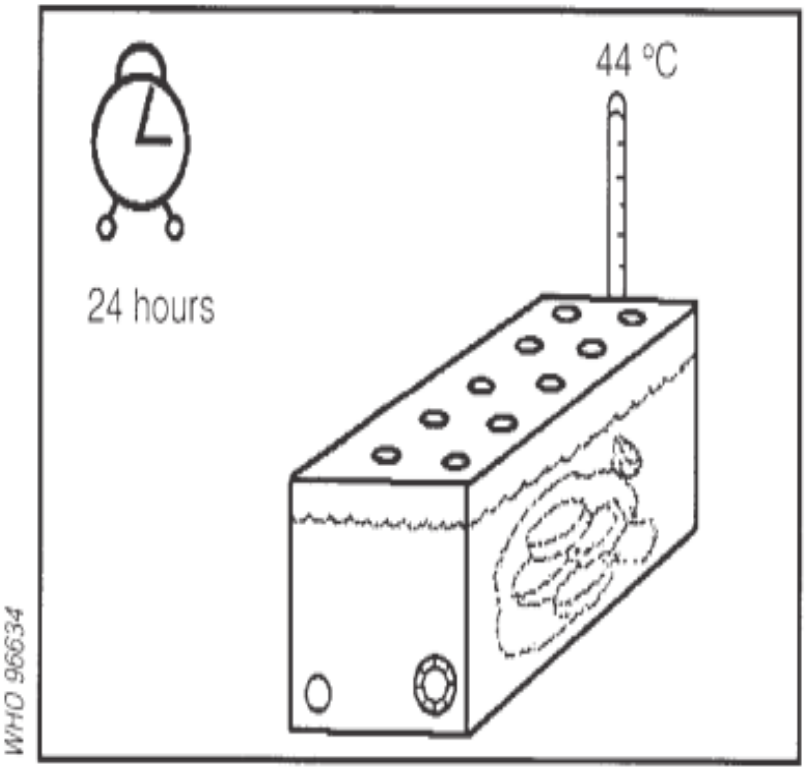
I. Place the dishes in an incubator at 44 ± 0.5 °C for 18–24 hours with 100% humidity. Alternatively, tight-fitting or sealed Petri dishes may be placed in waterproof plastic bags for incubation.



WHO 96633

Procedure

J. Submerge the bags in a water-bath maintained at 44 ± 0.5 °C for 18–24 hours. The plastic bags must be below the surface of the water throughout the incubation period. They can be held down by means of a suitable weight, e.g. a metal rack.



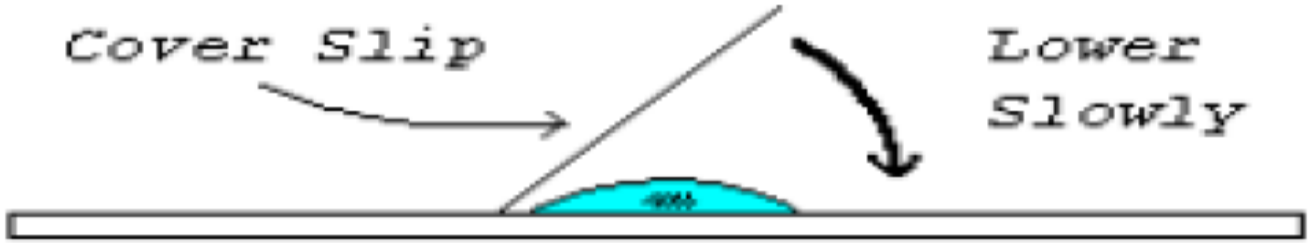
Calculations

$$\text{Thermotolerant coliforms per 100 ml} = \frac{\text{no. of thermotolerant coliform colonies counted}}{\text{no. of ml of sample filtered}} \times 100$$

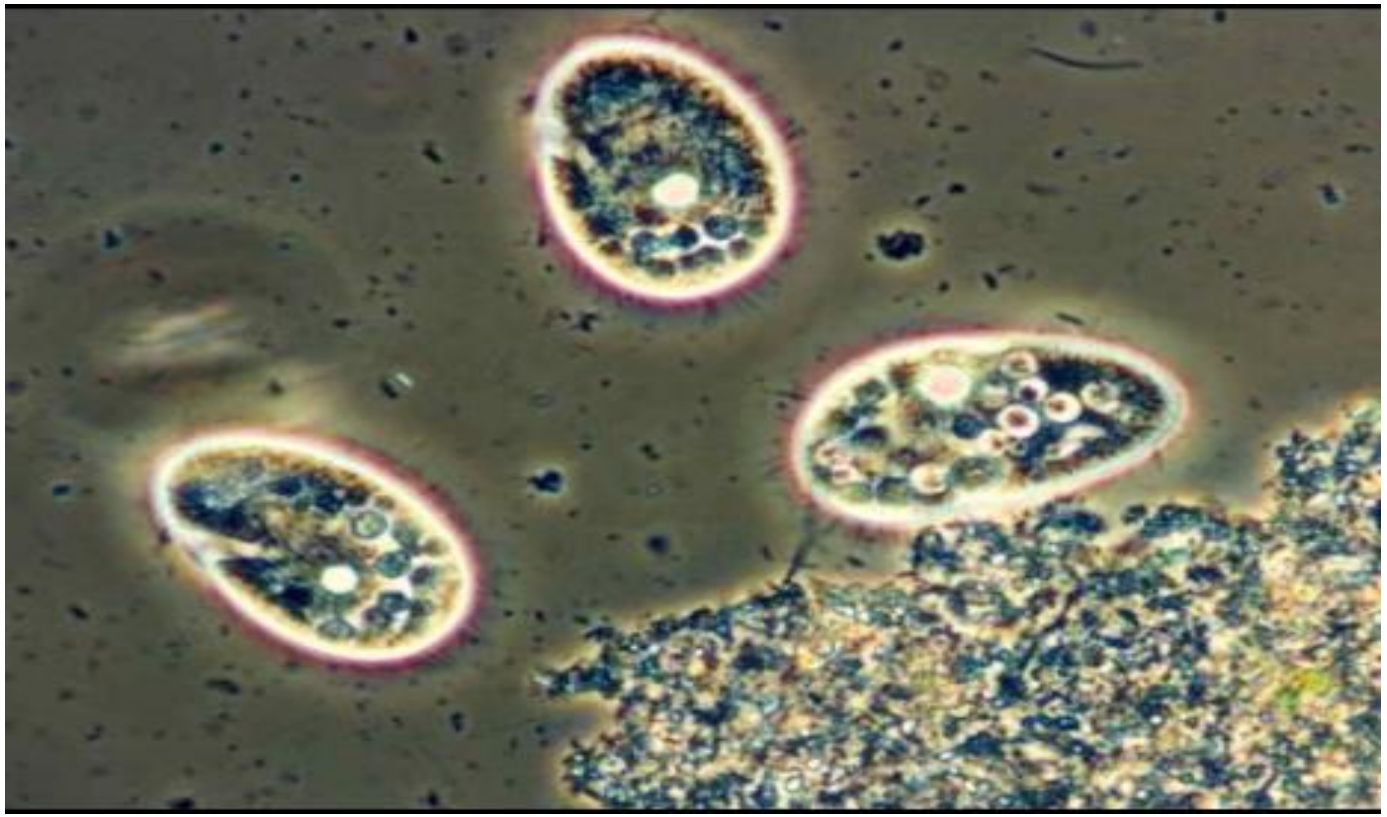
Microscopic examination

Microscopic examination

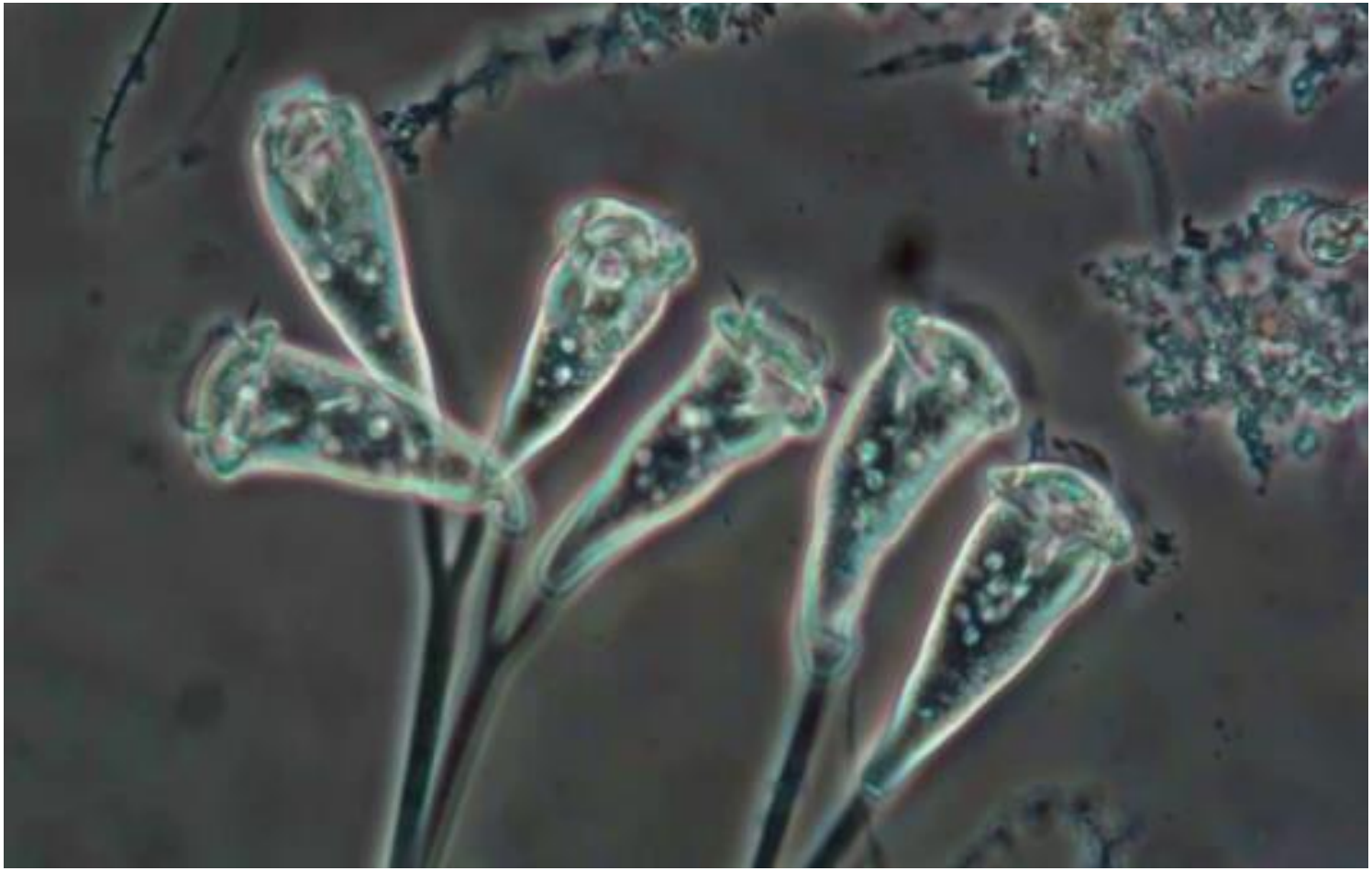
- Place a drop of sample on the slide using a pipet or eyedropper.
- Place a clean, dry cover slip onto the slide at a 45º so that one edge touches the droplet and the water spreads along the edge of the cover slip.
- Gently lower the cover slip, squeezing out air bubbles as you go.



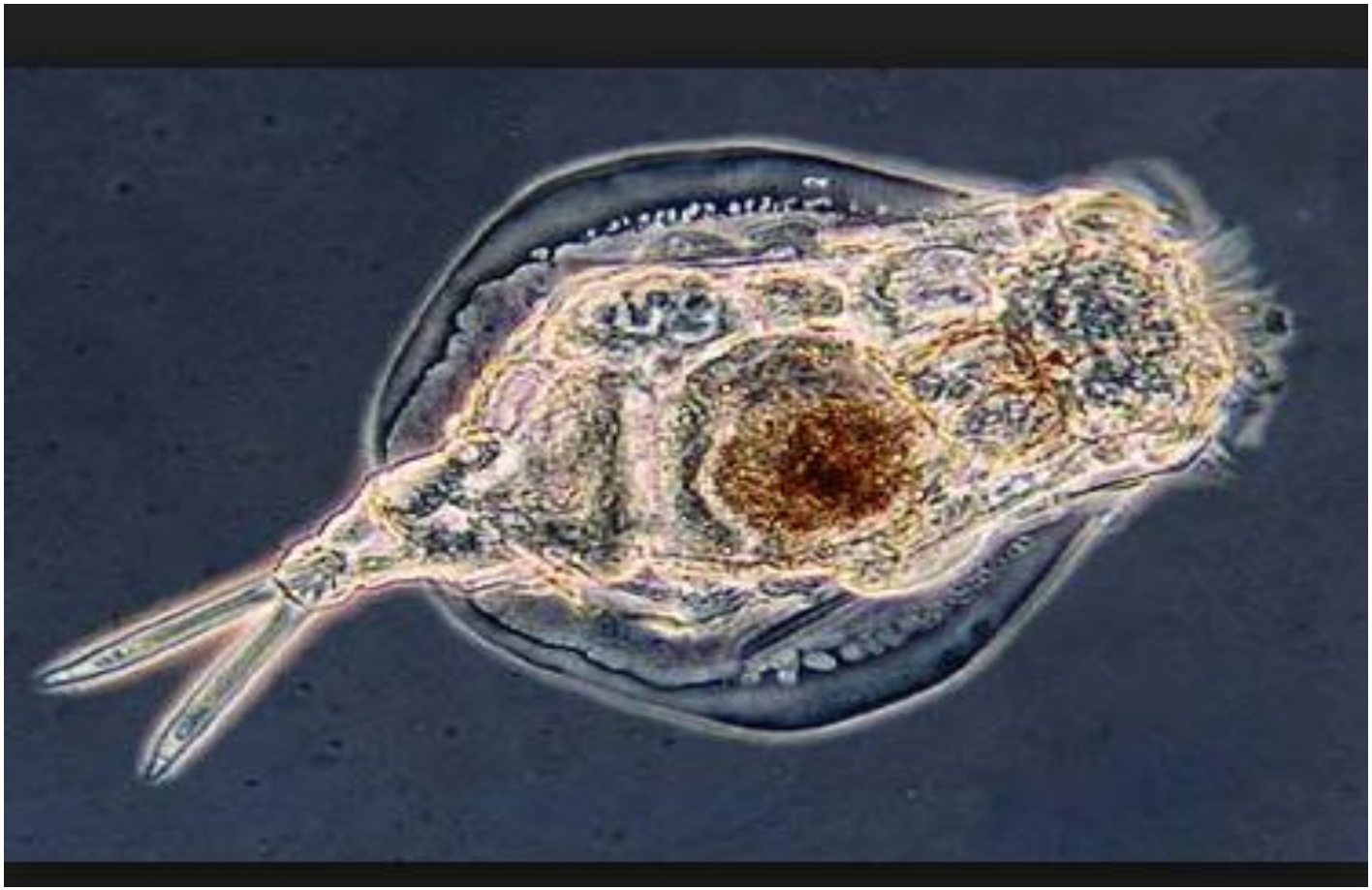
Free swimming ciliates



Stalkd ciliates

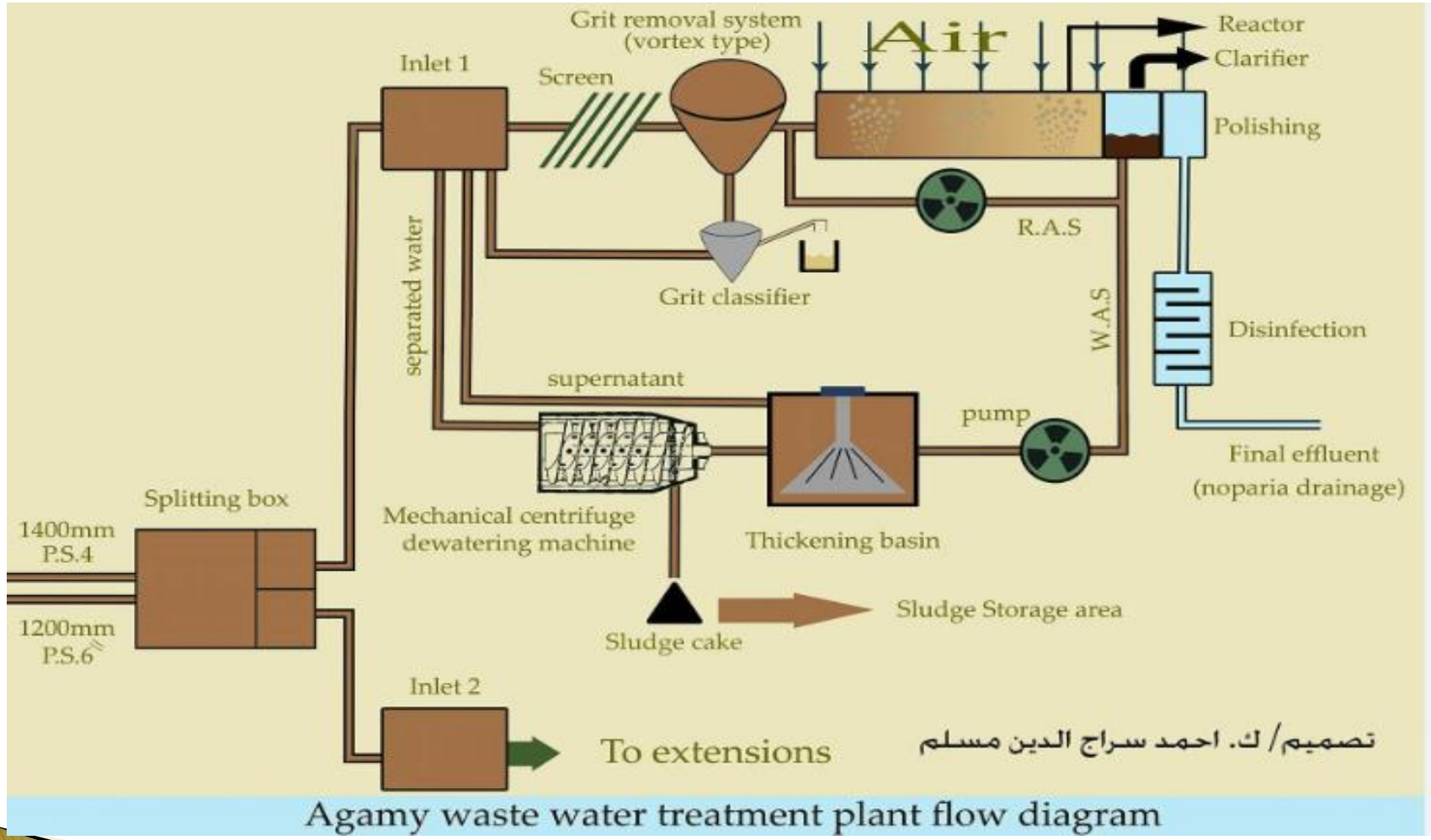


rotifers



Nematodes

WASTEWATER TREATMENT UNITS



Agamy waste water treatment plant flow diagram

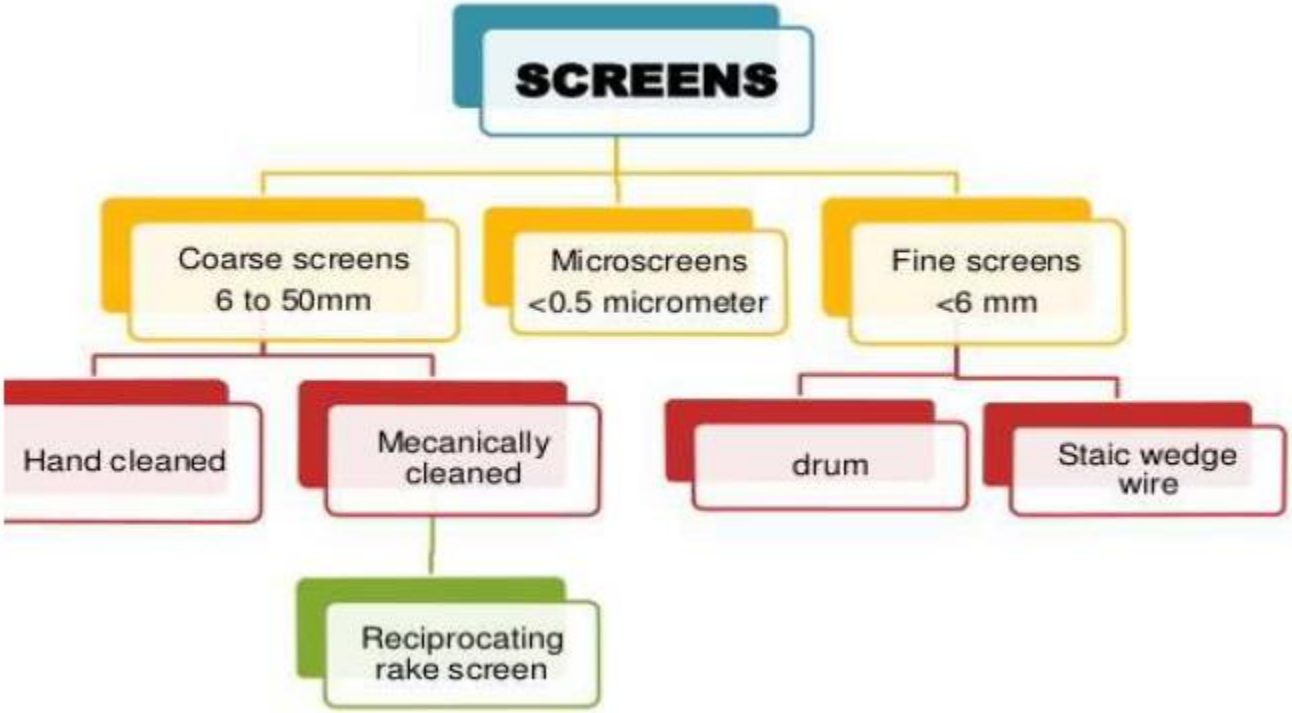
Preliminary treatment

- 1- Screening
- 2- Grit Removal

SCREENING

- removal of floating papers, rages, cloths, plastics, cans, stoppers, labels and suspended solids from the wastewater by coarse screening to protect pumps, valves and pipelines from damage or clogging by rags and large objects. The screen composed of parallel bars or rods is called a rack. The screens are typically made of stainless steel

SCREENING

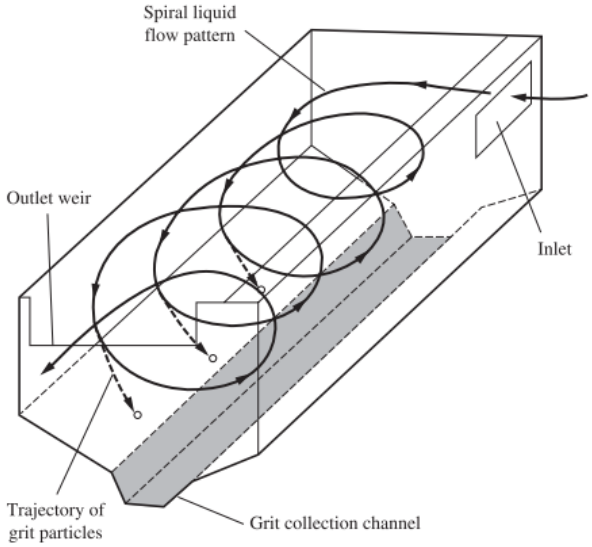

SCREENS
Coarse screens
6 to 50mm
Microscreens
<0.5 micrometer
Fine screens
<6 mm
Hand cleaned
Mecanically
cleaned
drum
Staic wedge
wire
Reciprocating
rake screen

SCREENING

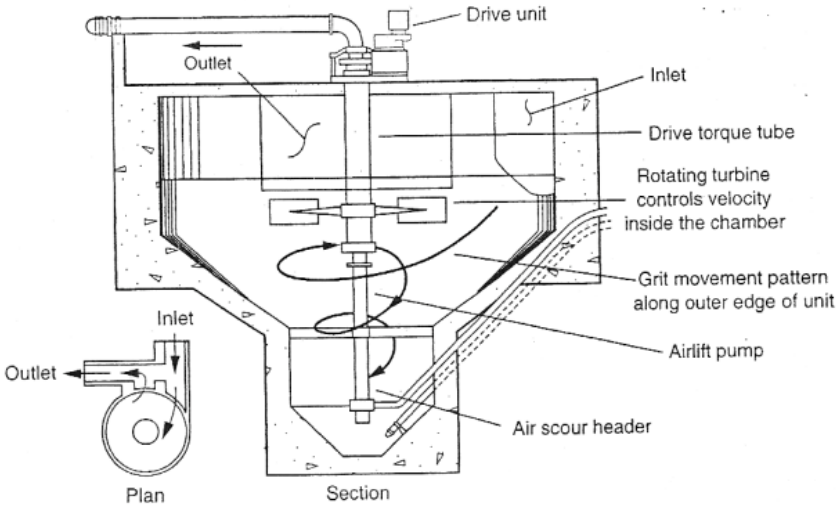
Grit Removal

- Sand, gravel, broken glass, egg shells, and other material having a settling velocity substantially greater than the organic material in wastewater is called grit. Grit removal is provided to protect mechanical equipment from abrasion and wear; reduce the formation of deposits in pipelines and channels
- A secondary, but none-the-less extremely desirable goal of the grit removal system is to separate the grit from the organic material in the wastewater. This separation allows the organic material to be treated in subsequent processes.

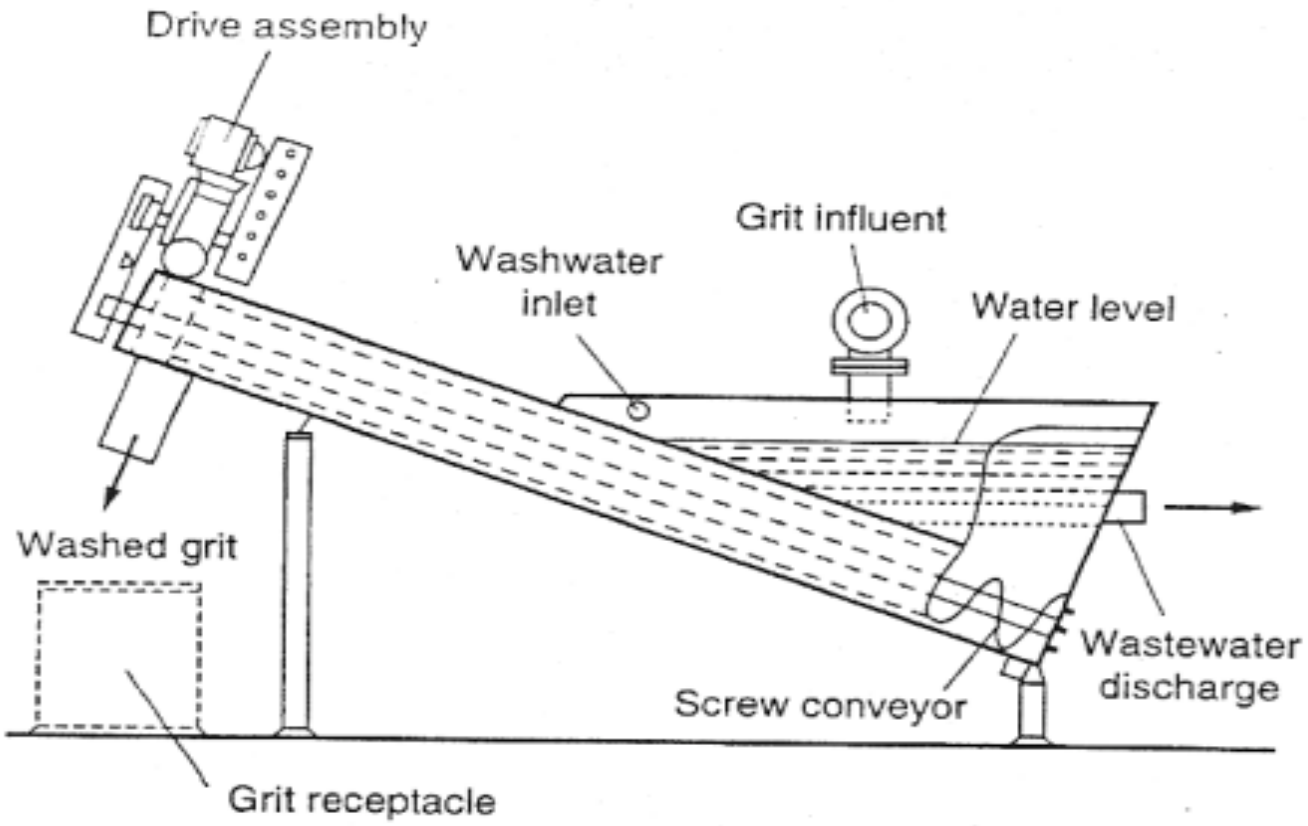
Aerated Grit Chamber



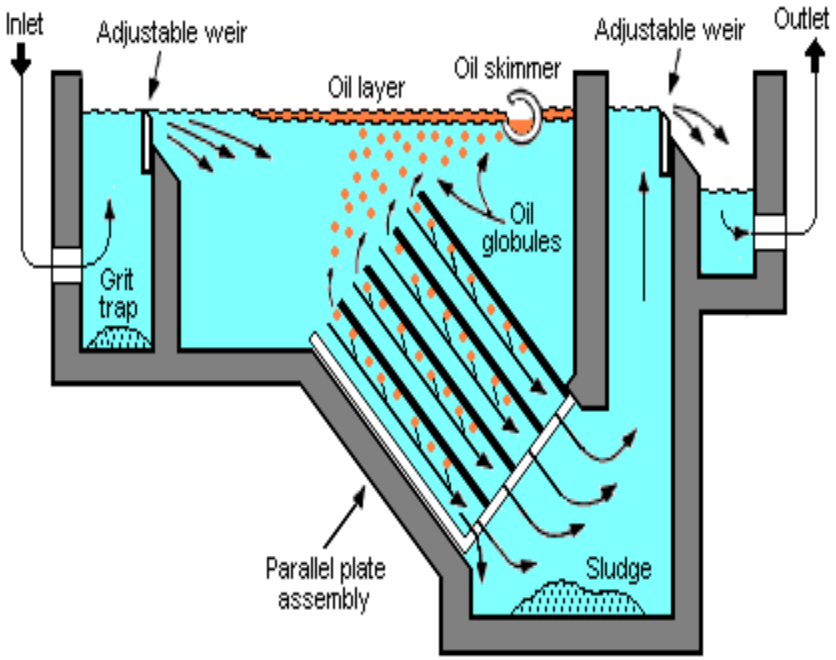
VORTEX SEPARATOR



Grit classifier



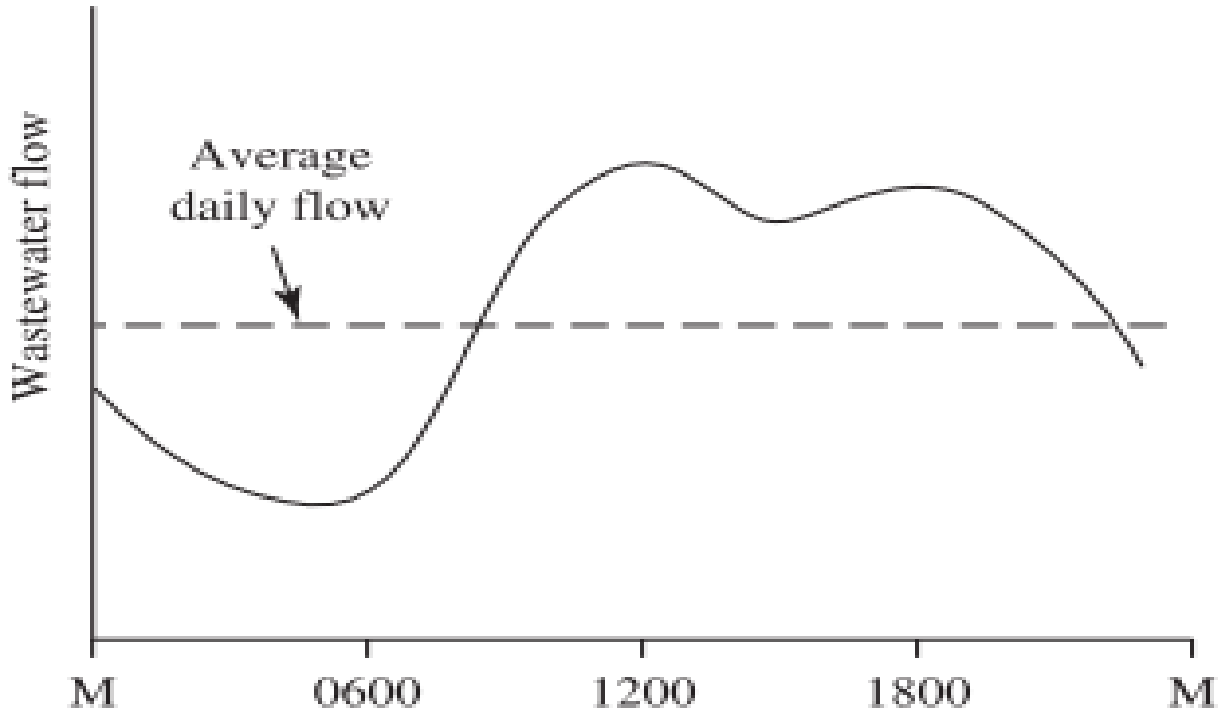
API SEPARATOR



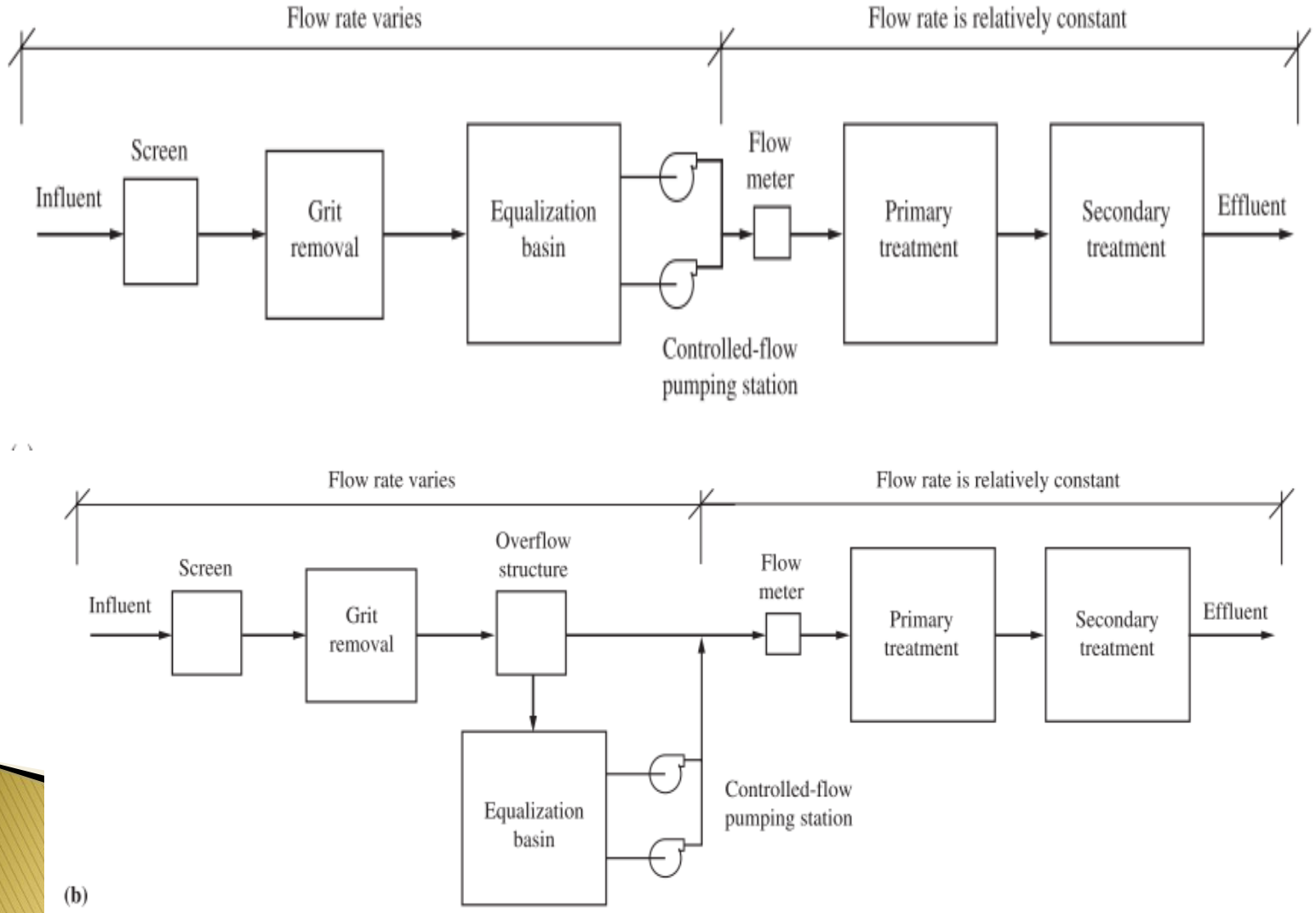
FLOW EQUALIZATION

- Wastewater does not flow into a municipal wastewater treatment plant at a constant rate. Even in dry weather, the flow rate varies from hour to hour, reflecting the living habits of the area served and variable process flows from industrial customers. Above-average sewage flows and strength occur in mid-morning.

FLOW EQUALIZATION



In-line and Off-line equalization tank



Activated sludge biological treatment

- Aeration
- Settling
- Sludge recycling

aeration

- Combination of blowers and air diffusers

Types of diffusers

Mechanical aerators

Jet aerators

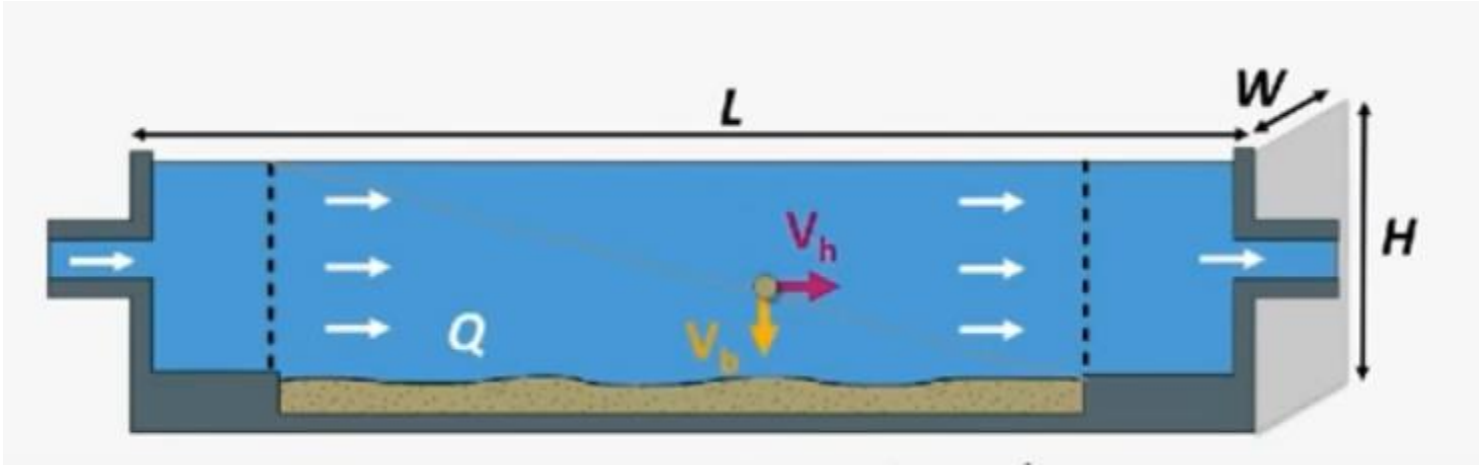
Settling tanks

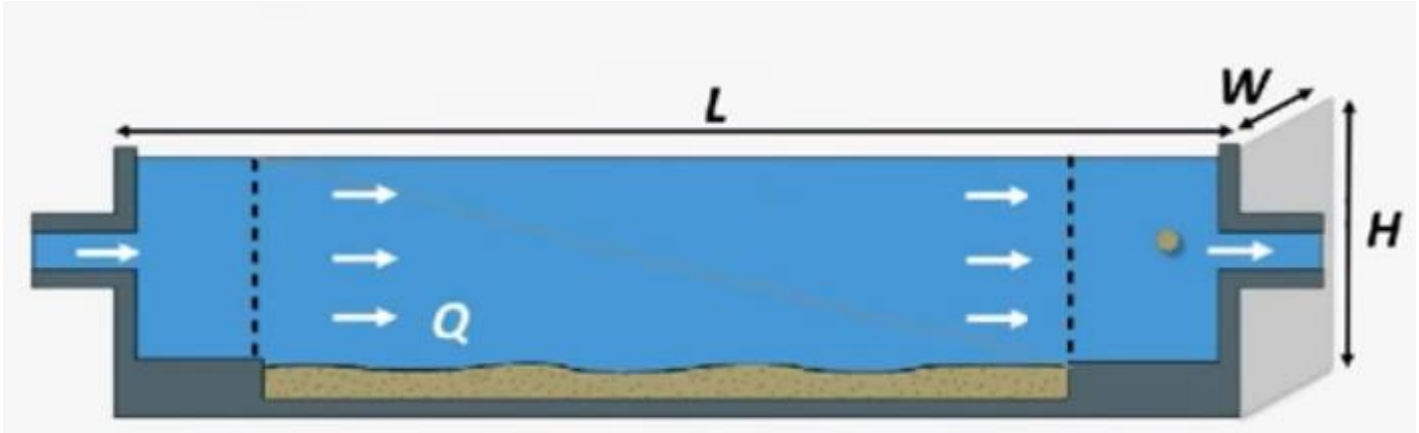
- DISCRETE VS FLOCULENT SETTLING
- DISCRETE DON'T DEPEND ON DEPTH
- FLOCULENT SETTLING THAT MEANS THERE IS COLLISIONS BETWEEN PARTICLES
- Horizontal velocity: Q/(W*D)
- Surface loading rate OR HYDRAULIC SURFACE LOAD OR HAZEN VELOCITY (SURFACE VELOCITY): Q/(L*W)
- OVERFLOW LOADING RATE: Q/WEIR length
- SCOURING VELOCITY (CRITICAL HORIZONTAL VELOCITY)

FACTORS AFFECTING ON PERFORMANCE OF SETTLING TANKS

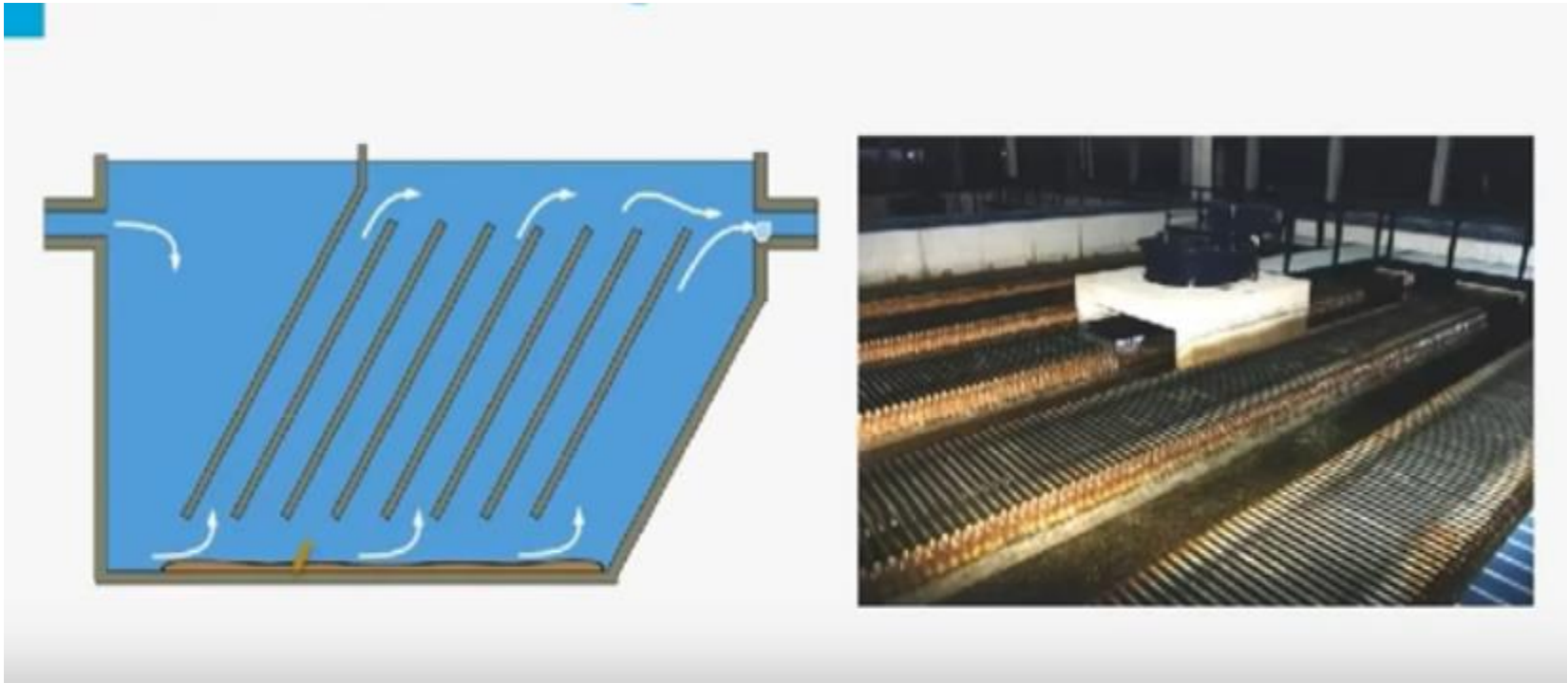
- Higher TURBULANT LOWER REMOVAL
- BAFFLES USED FOR DECREASE TURBULANT AND INCREASE STABILITY

IS THERE A DIFFERENCE

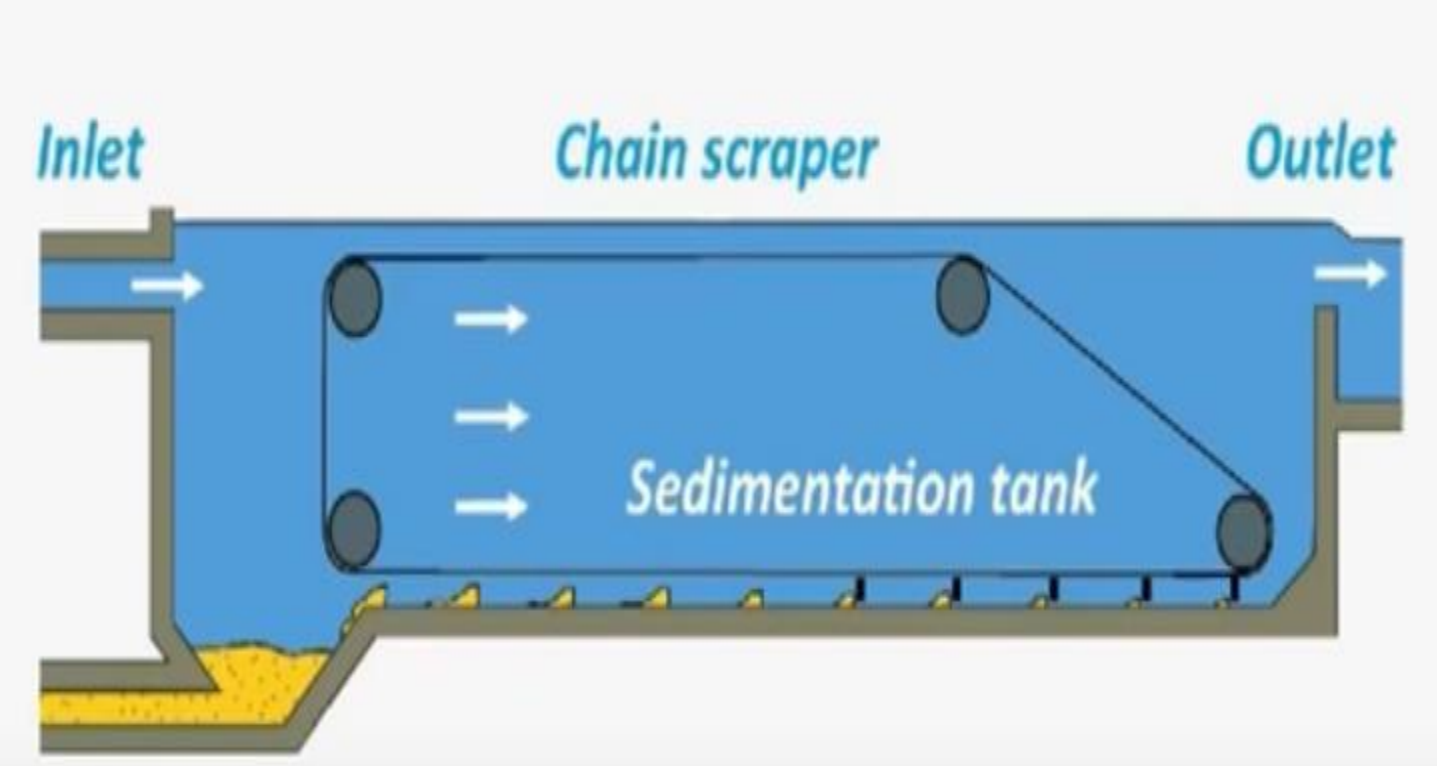




LAMELLA (DECREASE SURFACE LOADING)



SLUDGE REMOVAL



SDIMENTATION IN S.T.P

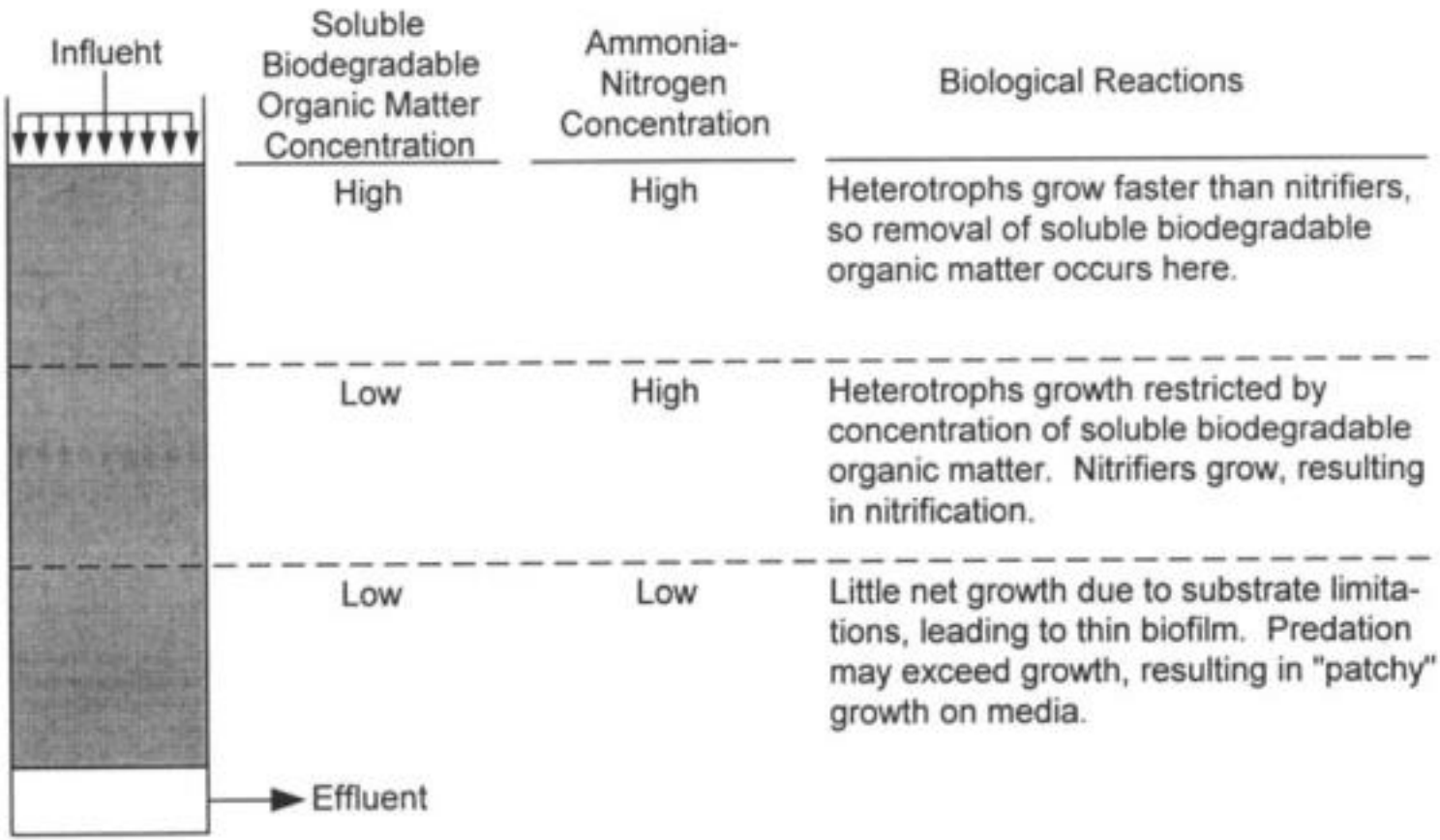
- GRIT REMOVAL
- PRIMARY SEDIMENTATION
- SECONDARY SEDIMENTATION
- THICKNERS

Activated sludge processes

- Suspended growth
- Attached growth

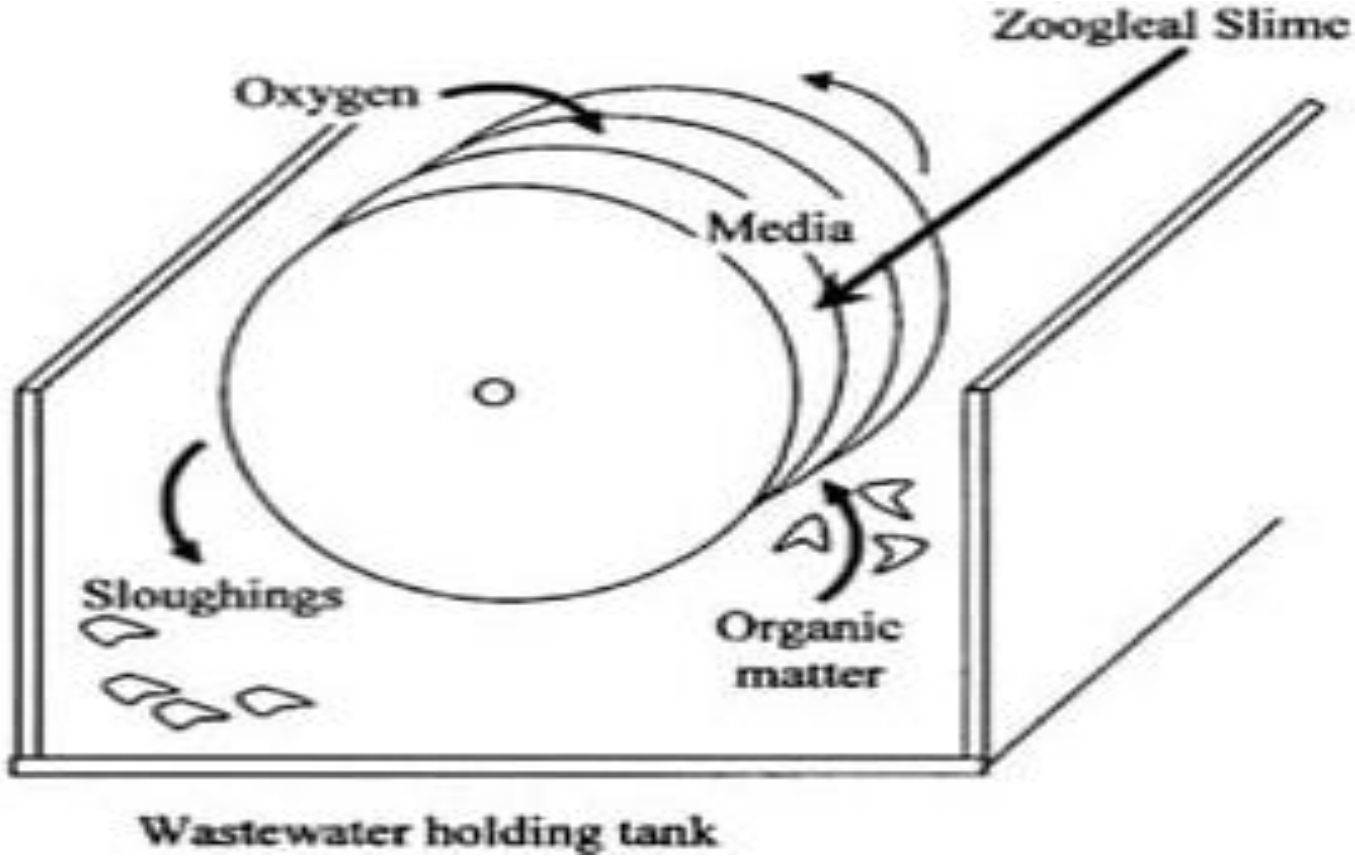
Attached growth process

- Trickling filters

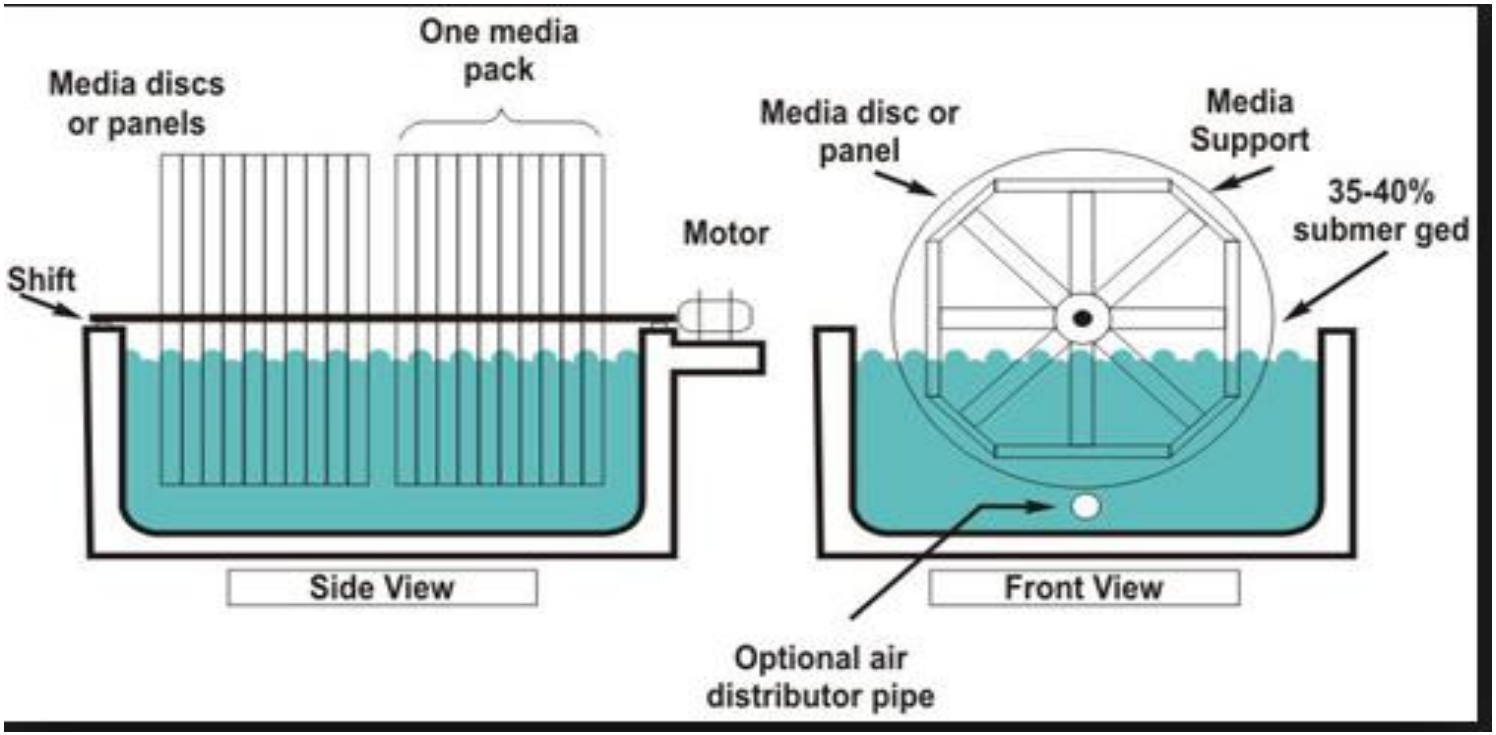


Attached growth process

- Rotating biological contactors (RBC)



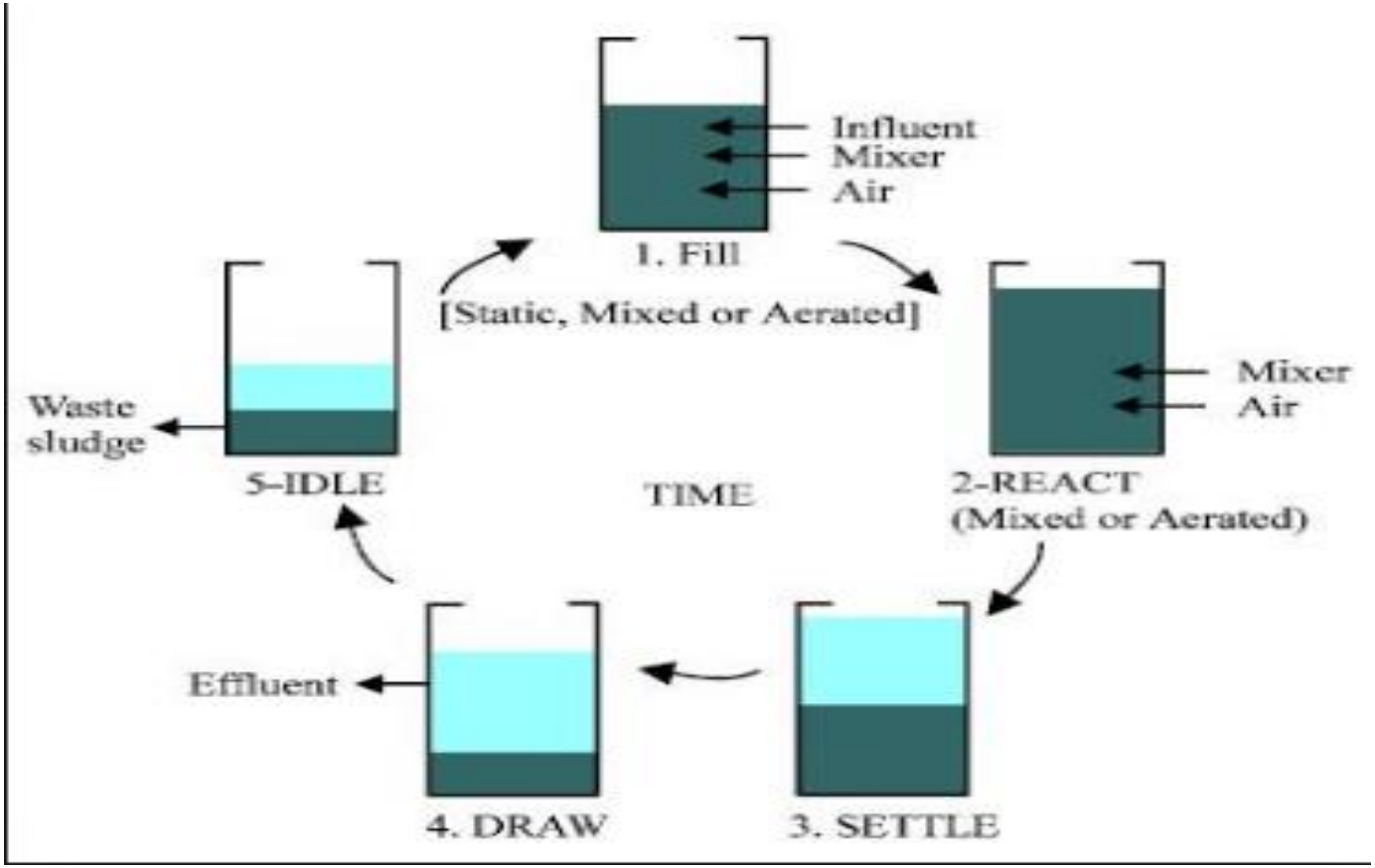
Rotating biological contactors (RBC)



SUSPENDED GROWTH

- NO MEDIA FOR GRAZING BACTERIA

Sequence batch reactor



decanter

DISINFECTION

CHLORINATION CHMISTRY

- Chlorine can be added to water as chlorine gas, aqueous sodium hypochlorite solution (liquid bleach), solid calcium hypochlorite produce

Hypochlorous acid (HOCl) is a weak acid that dissociates into hypochlorite ion (OCl^-) according to the following equation:

HOCl (Hypochlorous acid) $\Leftrightarrow$ H^+ + OCL^- (hypochlorite ion)

CHLORINATION CHMISTRY

The chemical reaction that creates Monochloramine (NH_2Cl) looks like this:

$$2NH_3 + 2HOCl \rightarrow 2\mathbf{NH_2Cl} + 2H_2O$$

Ammonia + Hypochlorous Acid yields Monochloramine + Water

Further chlorination of monochloramine creates Dichloramine ($NHCl_2$):

$$2NH_2Cl + 2HOCl \rightarrow 2\mathbf{NHCl_2} + 2H_2O$$

Monochloramine + Hypochlorous Acid yields Dichloramine + Water

And of course, even further chlorination yields the most noxious of chloramines that off-gasses from pools, Nitrogen Trichloride, aka Trichloramine (NCl_3):

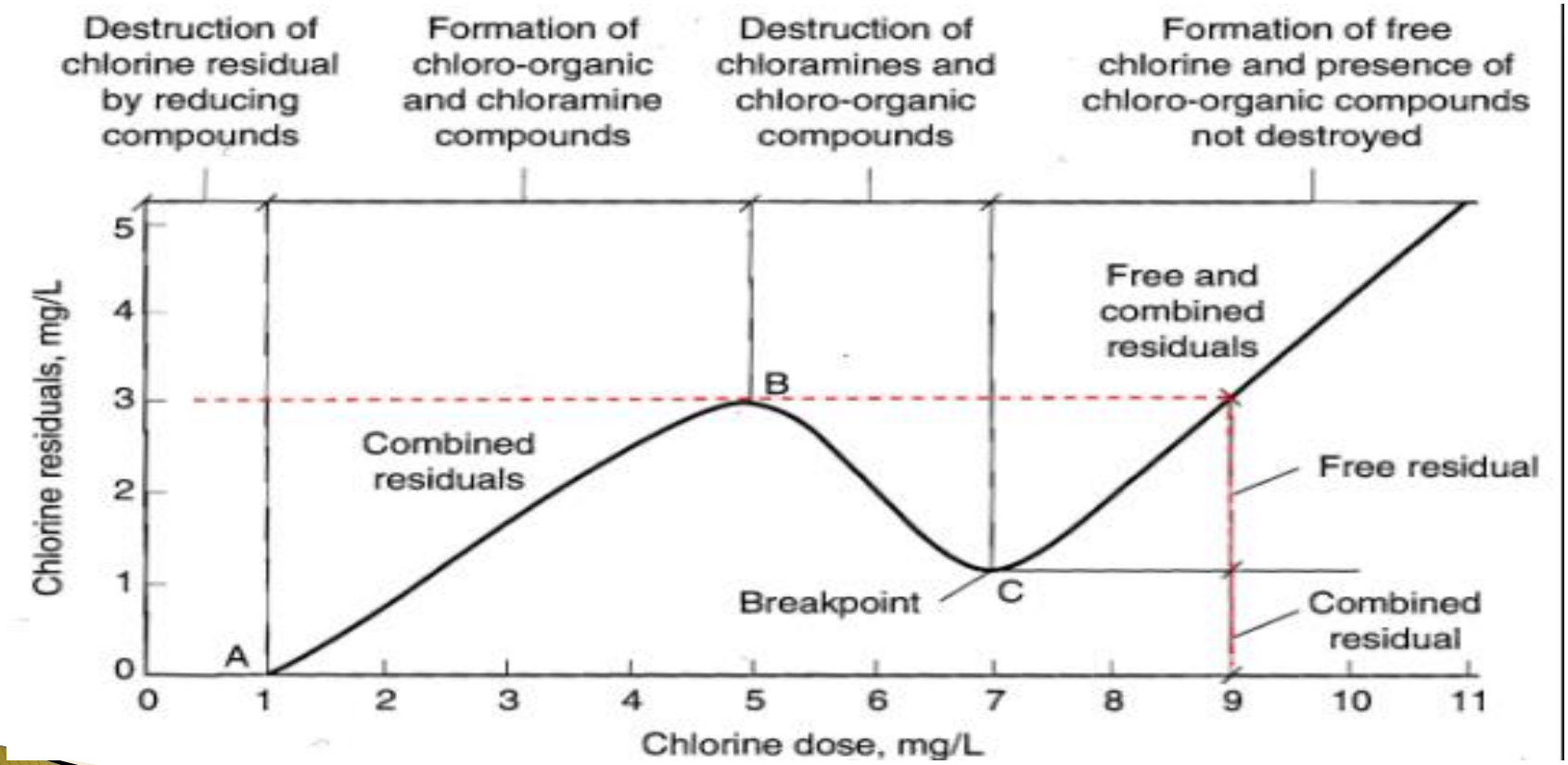
$$NHCl_2 + 3HOCl \rightarrow \mathbf{NCl_3} + 3H_2O$$

Dichloramine + Hypochlorous Acid yields Trichloramine + Water

Trichloramine is both volatile and unstable and is usually not allowed to form

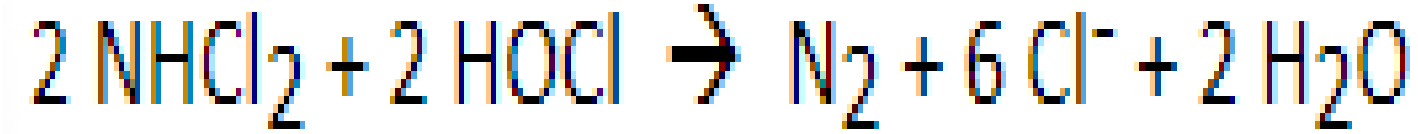
CHLORINATION CHMISTRY

CHLORINATION BREAK POINT



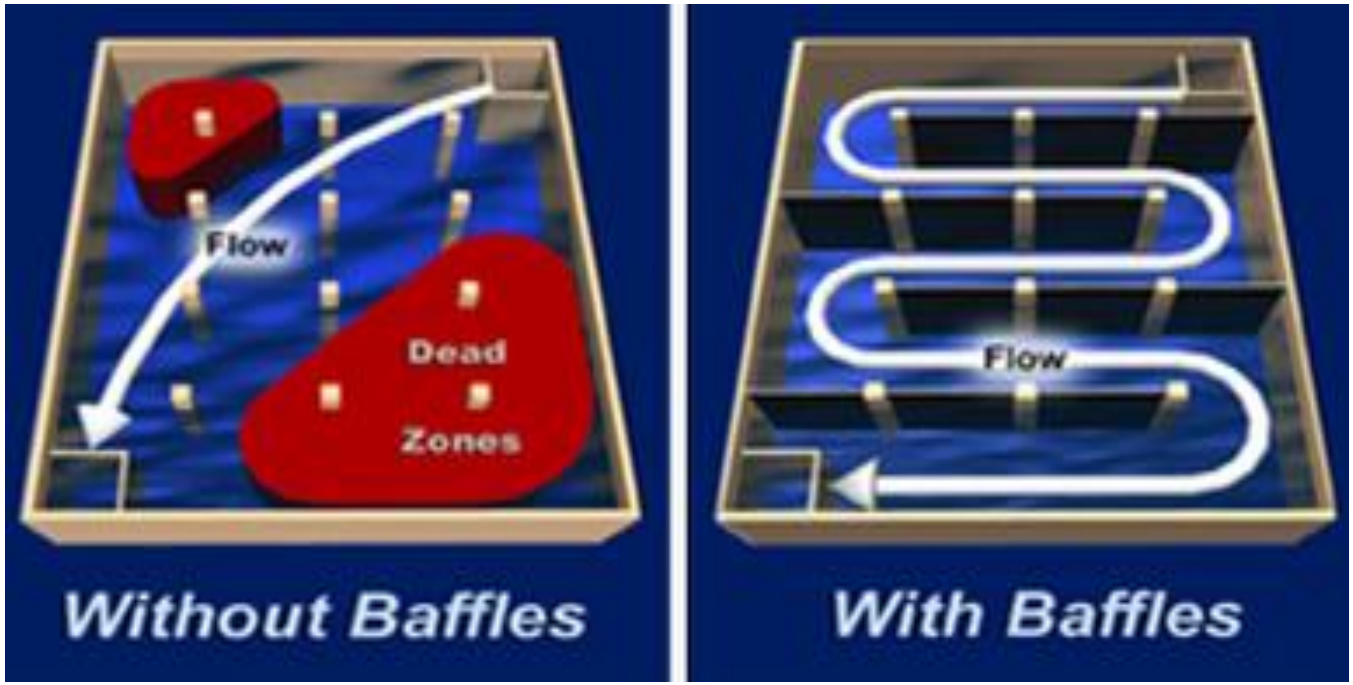
CHLORINATION CHMISTRY

- AT BREAK POINT if enough chlorine is added to bring the chlorine to ammonia ratio up to 10:1, the mono- and dichloramines are almost completely destroyed and converted back into less offensive nitrogen compounds and chloride salts:



CHLORINATION CONACT TIME

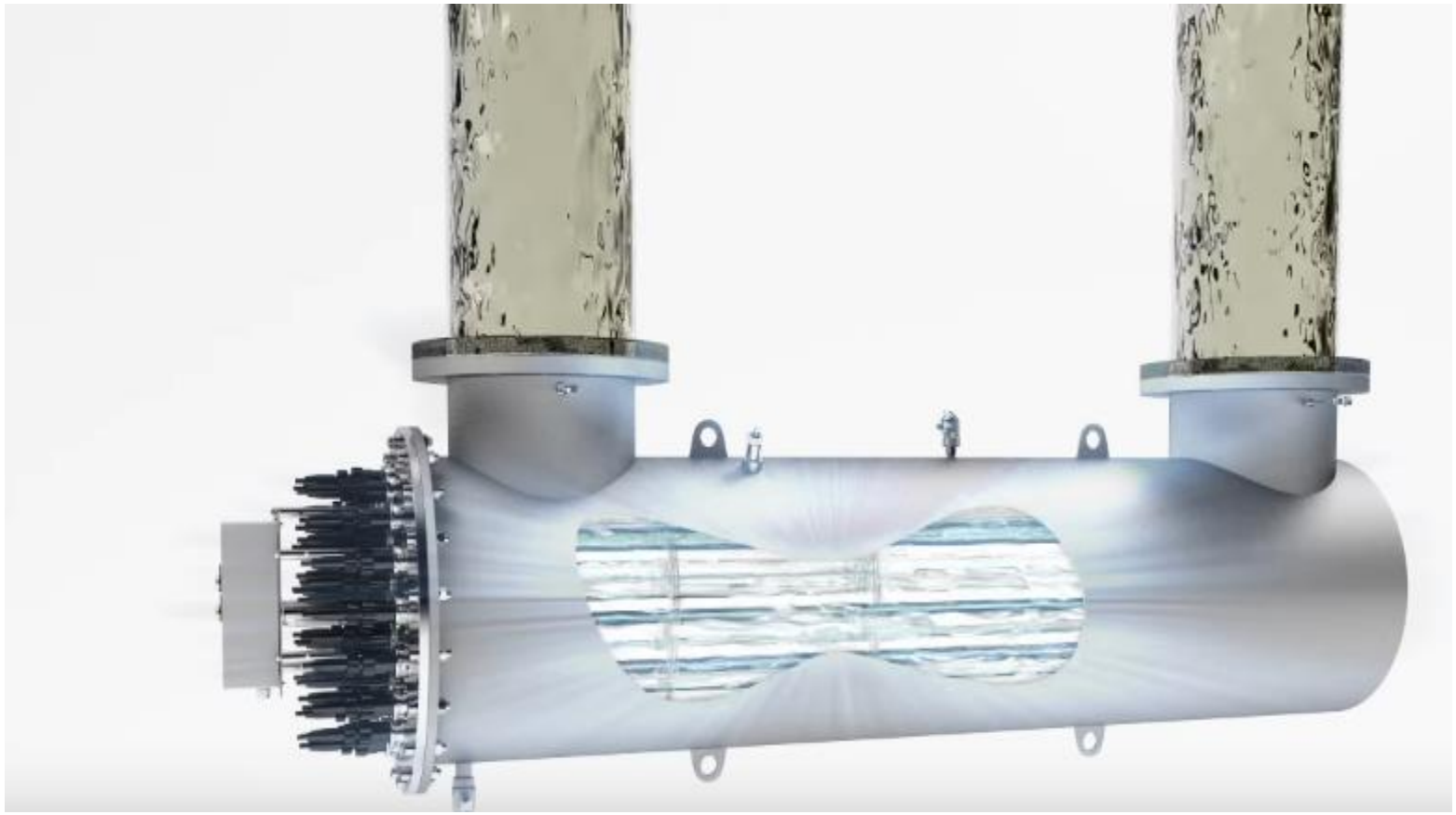
Contact time 30 min



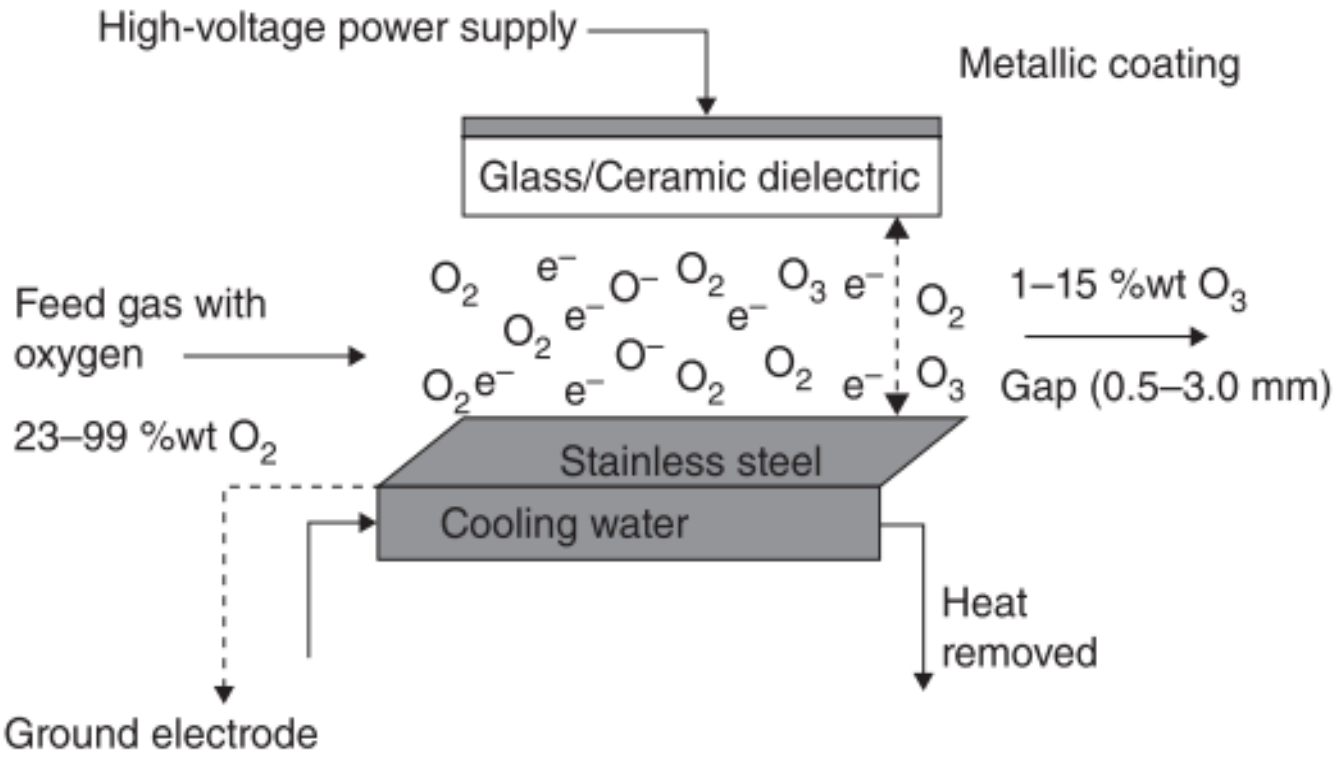
CHLORINE GAS SCRUBBING SYSTEM

- 1- CAUSTIC SOUDA SOLUTION STORAGE TANK
- 2- ABSORPTION TOWER
- 3- CAUSTIC SOUDA PUMPS
- 4- BLOWERS
- 5- CHLORINE GAS LEAK DETECTORS (3PPM)
- 6- CONTROL PANEL

UV disinfection



Ozonation


High-voltage power supply
Metallic coating
Glass/Ceramic dielectric
Feed gas with oxygen
23–99 %wt O_2
O_2 e^- O^- O_2 O_3 e^- O_2
O_2 e^- e^-
O_2 e^- e^- O^- O_2 O_2 e^- O_3
1–15 %wt O_3
Gap (0.5–3.0 mm)
Stainless steel
Cooling water
Heat removed
Ground electrode

Ozonation

- spark across a dielectric to form a corona. The main component to any corona discharge power supply is a transformer to increase voltage from the standard 120 or 220 VAC up to 20,000 volts. This high voltage will create the spark (corona) necessary for ozone generation.

Ozonation

Gas Quality

- A high quality feed gas is essential to the long term operability of the ozone generator. The feed gas must be extremely dry, free of particulates and hydrocarbons, relatively cool, and at the appropriate pressure and flow for treatment.

SAND FILTERS

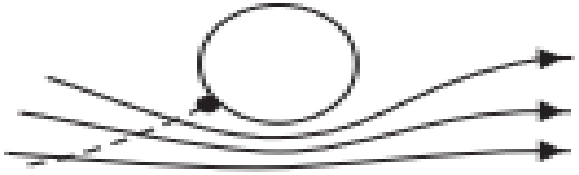
- SLOW SAND FILTERS
- RAPID GRAVITY SAND FILTERS
- RAPID PRESSURE SAND FILTERS

FILTRATION MECHANISMS

Gravity
(a)

Diffusion
(b)

Interception
(c)



Hydrodynamic effects
(d)

Inertia
(e)

FILTRATION MECHANISMS

Chemical transformations

$4 \cdot Fe^{2+} + O_2 + 8 \cdot HCO_3^- \rightarrow 4 \cdot Fe(OH)_3 \downarrow + 8 \cdot H_3O^+$

$2 \cdot Mn^{2+} + O_2 + 6 \cdot H_2O \rightarrow 2 \cdot MnO_2 \downarrow + 4 \cdot H_3O^+$

Results in clogging of the filter

1 mg Fe^{2+} uses 0.14 mg/l O_2

1 mg Mn^{2+} uses 0.29 mg/l O_2

FILTRATION MECHANISMS

Biological transformations

$2 \cdot NH_4^+ + 3 \cdot O_2 + 2 \cdot H_2O \rightarrow 2 \cdot NO_2^- + 4 \cdot H_3O^+$

$2 \cdot NO_2^- + O_2 \rightarrow 2 \cdot NO_3^-$

Nitrosomonas and nitrobacter

1 mg NH_4^+ uses 3.55 mg/l O_2

AOC, organic material

$CH_2O + O_2 \rightarrow CO_2 + H_2O$

Bacteria production:

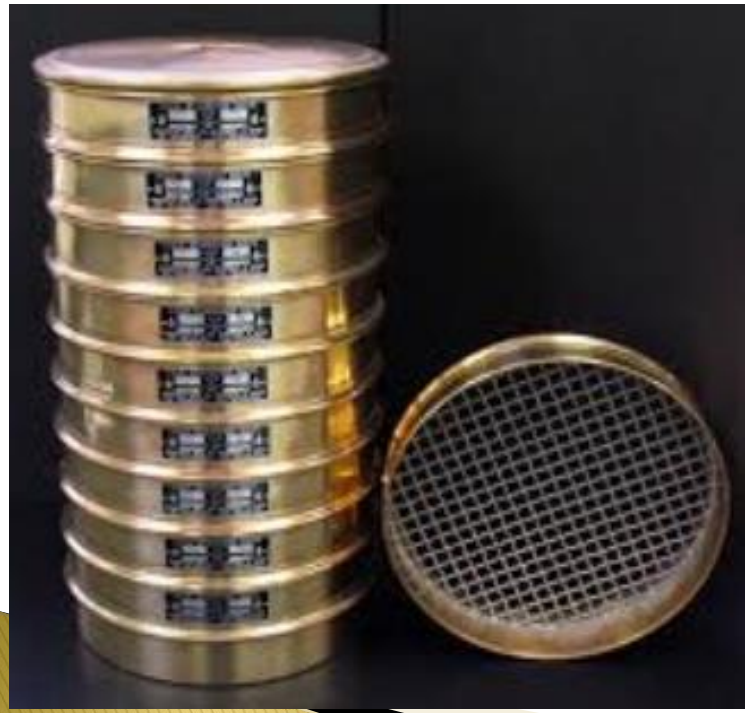
nitrosomonas	0.15 g bacteria/ g ammonia
nitrobacter	0.06 g bacteria/ g nitrite
methane	0.10 g bacteria/ g methane

$CH_4 + 2 \cdot O_2 \rightarrow 2 \cdot H_2O + CO_2$

1 mg/l CH_4 uses 4 mg/l O_2

MEDIA

- GRAIN SIZE
- EFFECTIVE SIZE (SIEVE TEST EQUIPMENT)

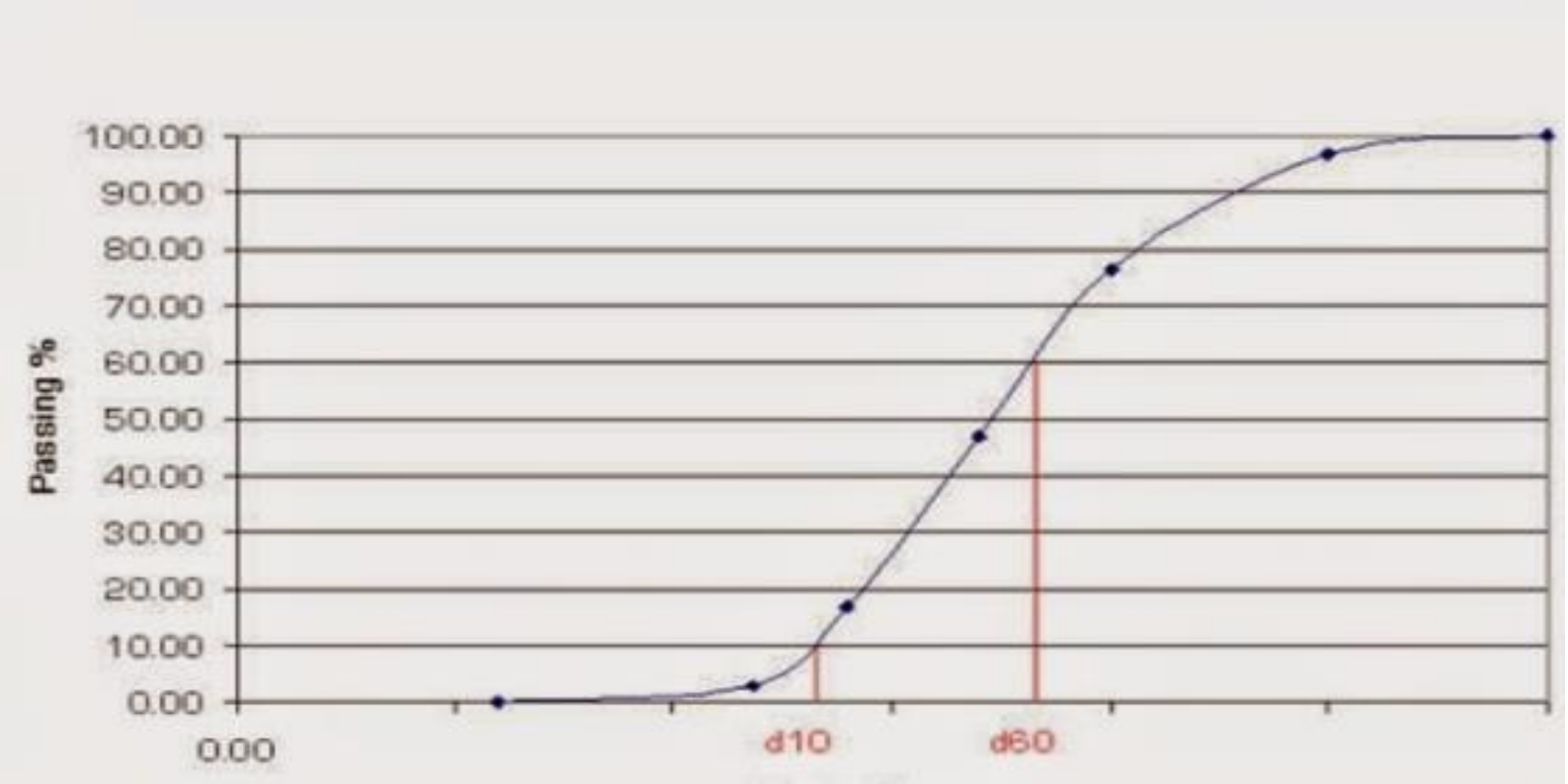


- EFFECTIVE SIZE: d_{10} (pass 10%)
- Curvature coefficient $U = \frac{d_{60}}{d_{10}}$
- Curvature coefficient for good design $\simeq$ 1
- Porosity (1 litr water – I litre dry media)

CALCULATIONS

IS Sieve Size (mm)	Weight retained (kg)	% Weight retained	Cumulative % weight retained	Cumulative % weight passing
4.75	0.0265	2.65	2.65	97.35
2.36	0.0305	3.05	5.70	94.30
1.18	0.121	12.1	17.80	82.20
0.6	0.238	23.8	41.60	58.40
0.3	0.367	36.7	78.35	21.65
0.15	0.153	15.3	93.65	6.35

CALCULATIONS



SAND FILTERS

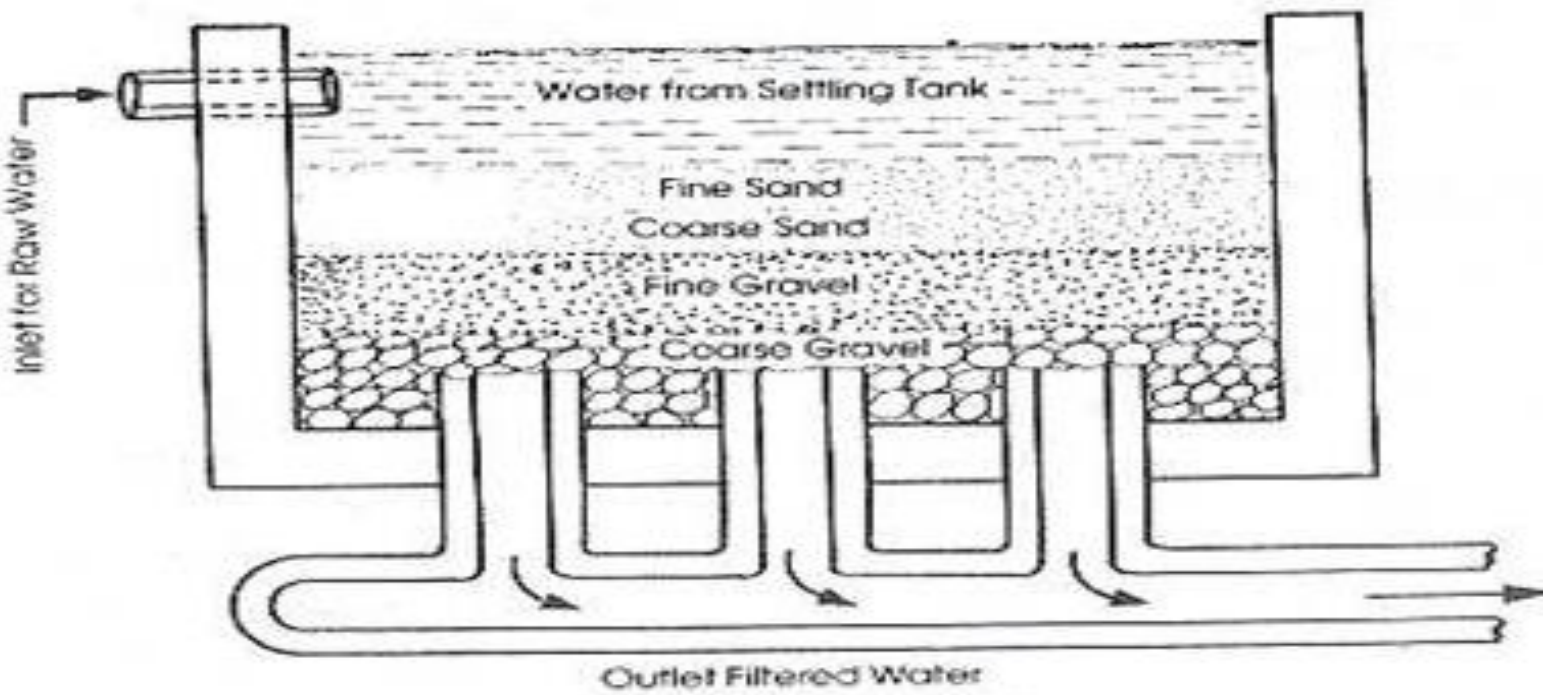


Fig. 5.3 : Slow sand filter.

SAND FILTERS (TERTIARY TREATMENT)

Characteristics	Rapid Sand Filter	Slow Sand Filter
Filtration rate [m/h]	5 - 15	0.08 - 0.25
Media effective size [mm]	0.5 - 1.2	0.15 - 0.30
Bed depth [m]	0.6 - 1.8	0.9 - 1.5
Run length	1 – 4 days	1 – 6 months
Ripening period	15 min - 2 h	Several days
Regeneration method	Backwashing	Scraping
Maximum raw-water turbidity	Unlimited with proper pretreatment	10 NTU

Sludge story

- Primary sludge
- RAS (return activateed sludge)
- WAS (waste activated sludge)
- Thickener
- Dry bed
- Centrifugal dryer
- Gravity belt thickner
- Belt press
- Composting
- Incentration
- Landfilling
- Pyrolysis
- digester

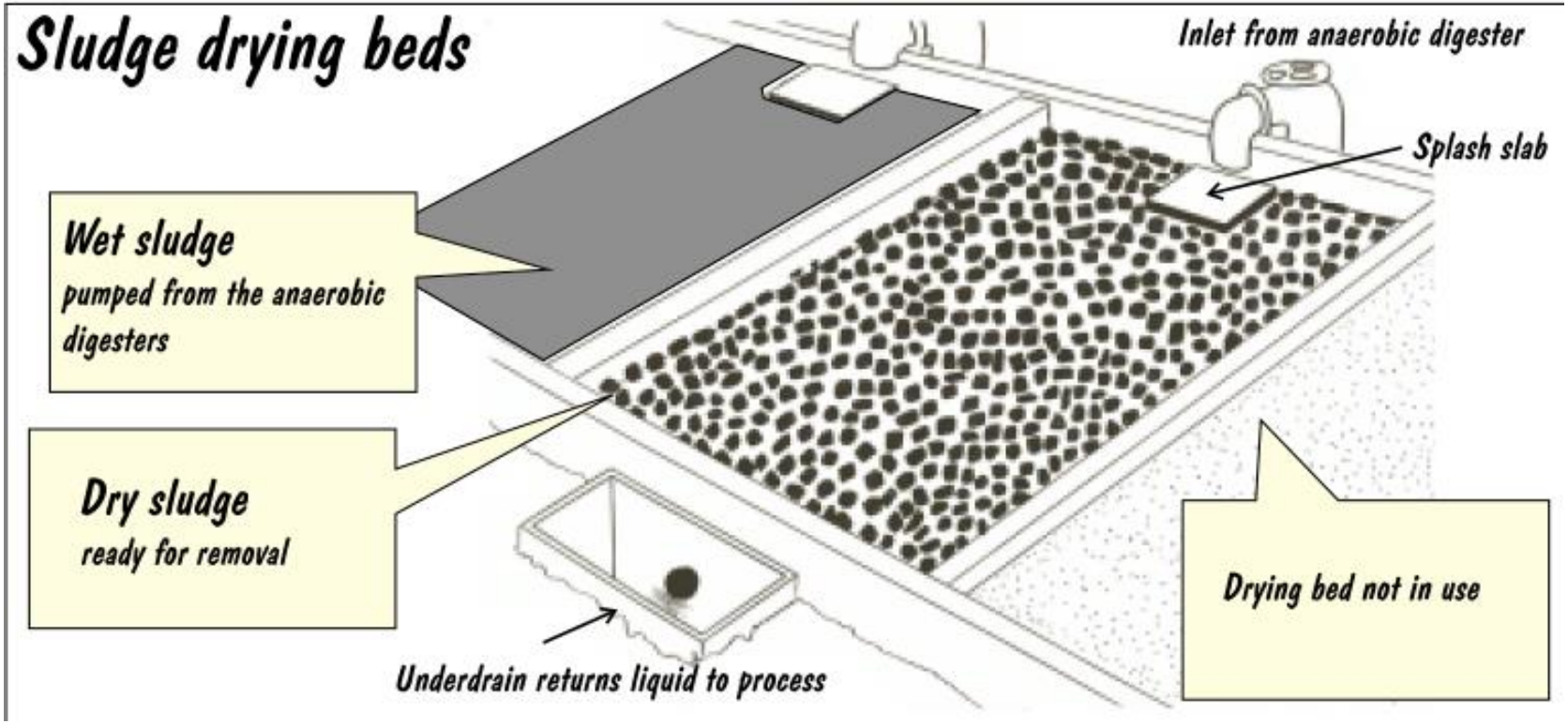
Primary vs. secondary sludge

- Primary sludge have higher organic content (less stabilized) with bad odor

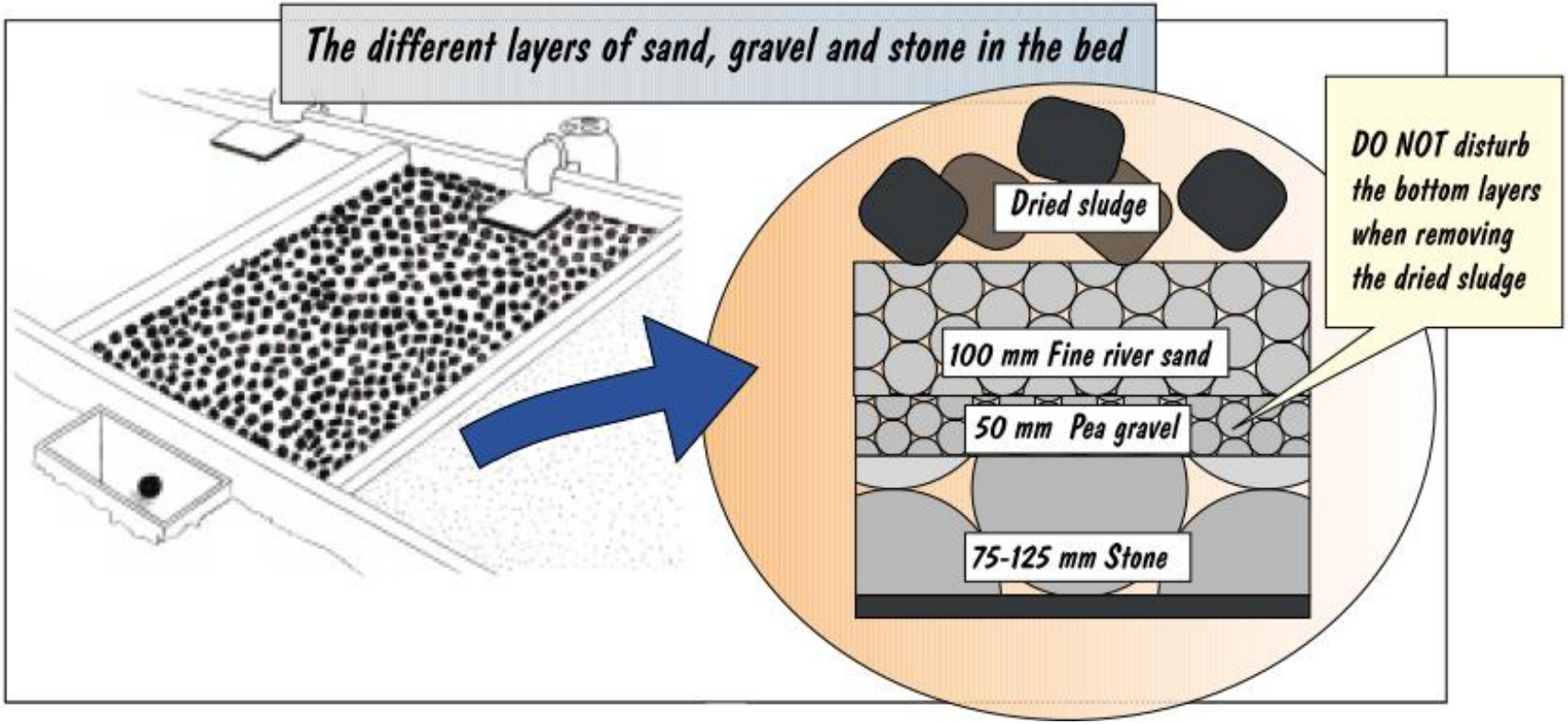
Sludge dewatering (drying beds)

- Sludge drying beds are provided to allow surplus sludge that is withdrawn from the process to dry for easier handling. Sludge drying relies on an underground drainage system as well as sunshine. Liquid from the underdrains should be returned to the sewage treatment process for further treatment.

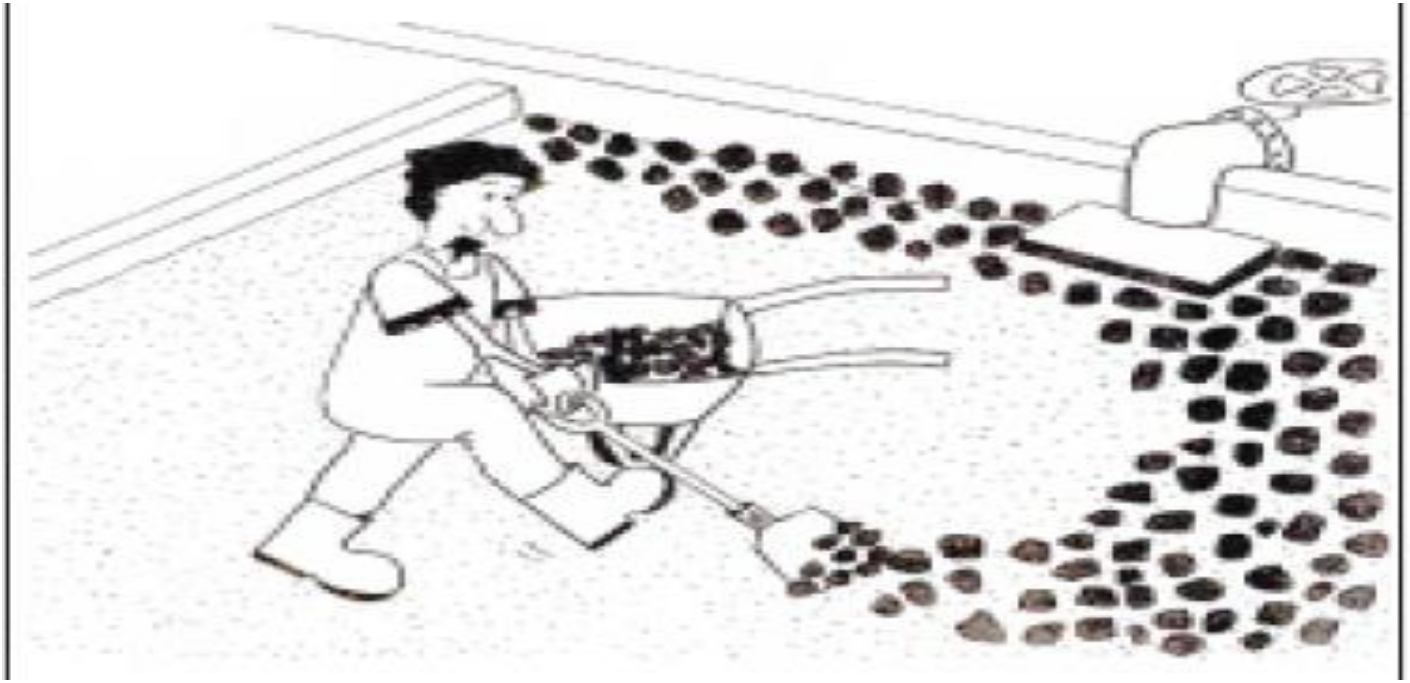
Sludge dewatering (drying beds)



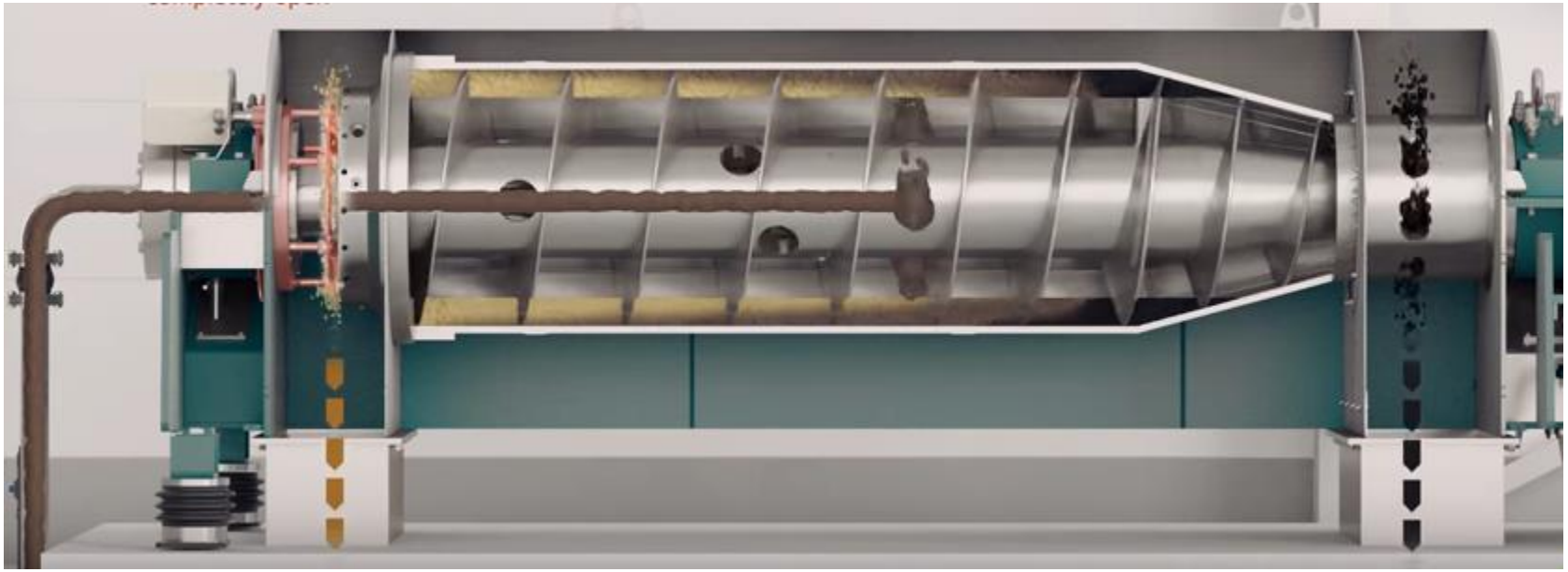
Sludge dewatering (drying beds)



Sludge dewatering (drying beds)



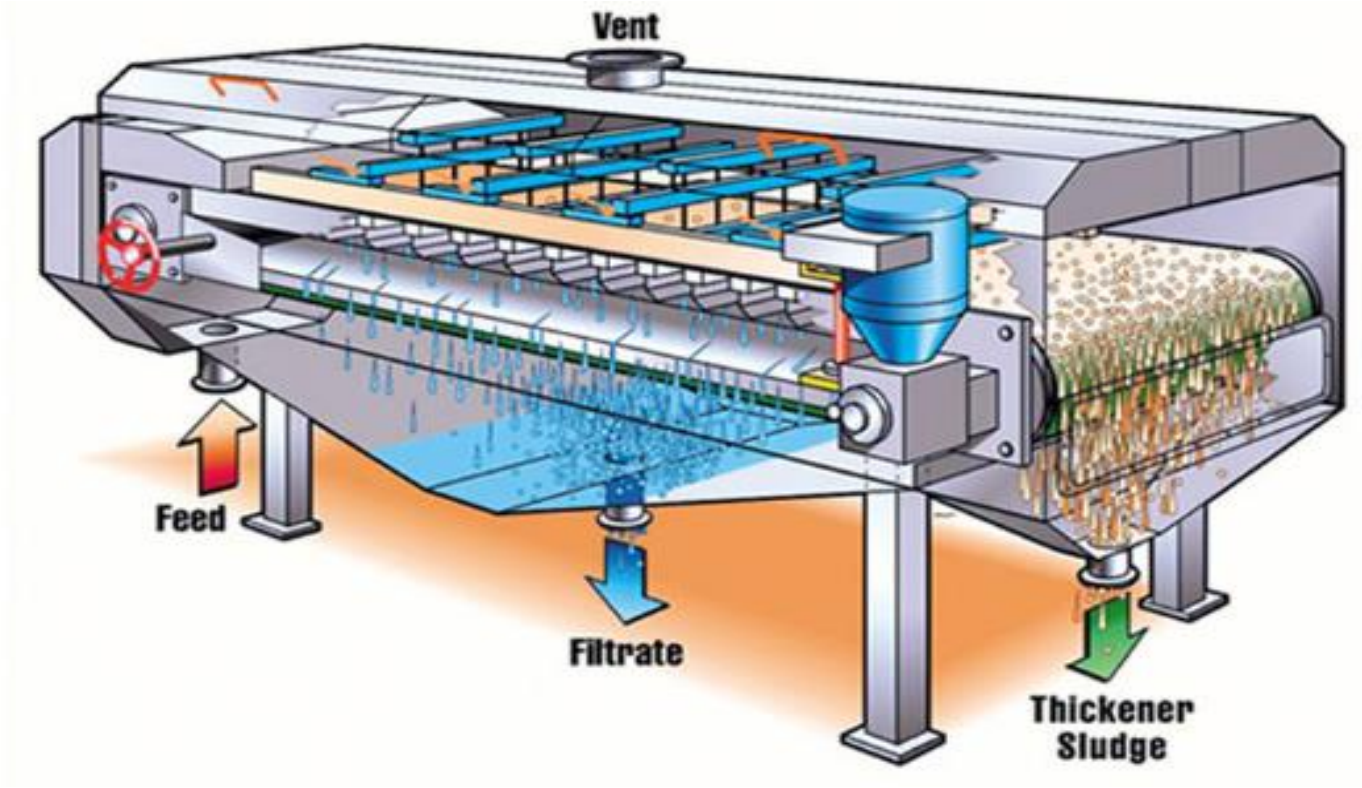
Sludge dewatering (Decanter centrifuge)



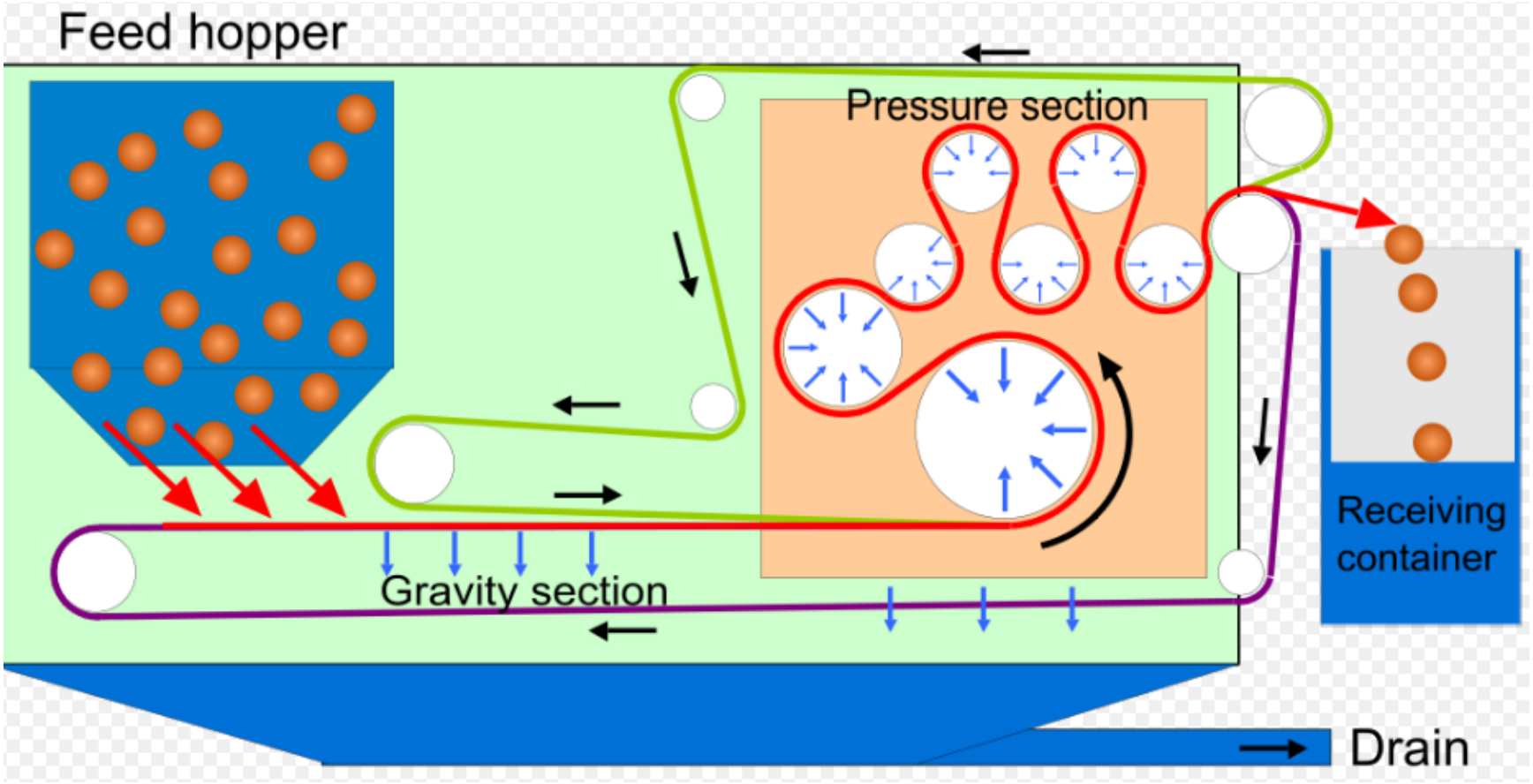
Gravity belt thickener

- designed for continuous operation, low polymer usage, low maintenance, and long operational life in the highly corrosive environment of waste treatment.

Gravity belt thickener



Filter press



Anaerobic digester

- Hydrolysisparticulates are solubilized and large polymers converted into simpler monomers
- Acidogenesis: A biological reaction where simple monomers are converted into volatile fatty acids;
- Acetogenesis: A biological reaction where volatile fatty acids are converted into acetic acid, carbon dioxide, and hydrogen
- Methanogenesis: A biological reaction where acetates are converted into methane and carbon dioxide.

Anaerobic digester

Typical composition of biogas

Compound	Formula	%
Methane	CH_4	50–75
Carbon dioxide	CO_2	25–50
Nitrogen	N_2	0–10
Hydrogen	H_2	0–1
Hydrogen sulfide	H_2S	0–3
Oxygen	O_2	0–0

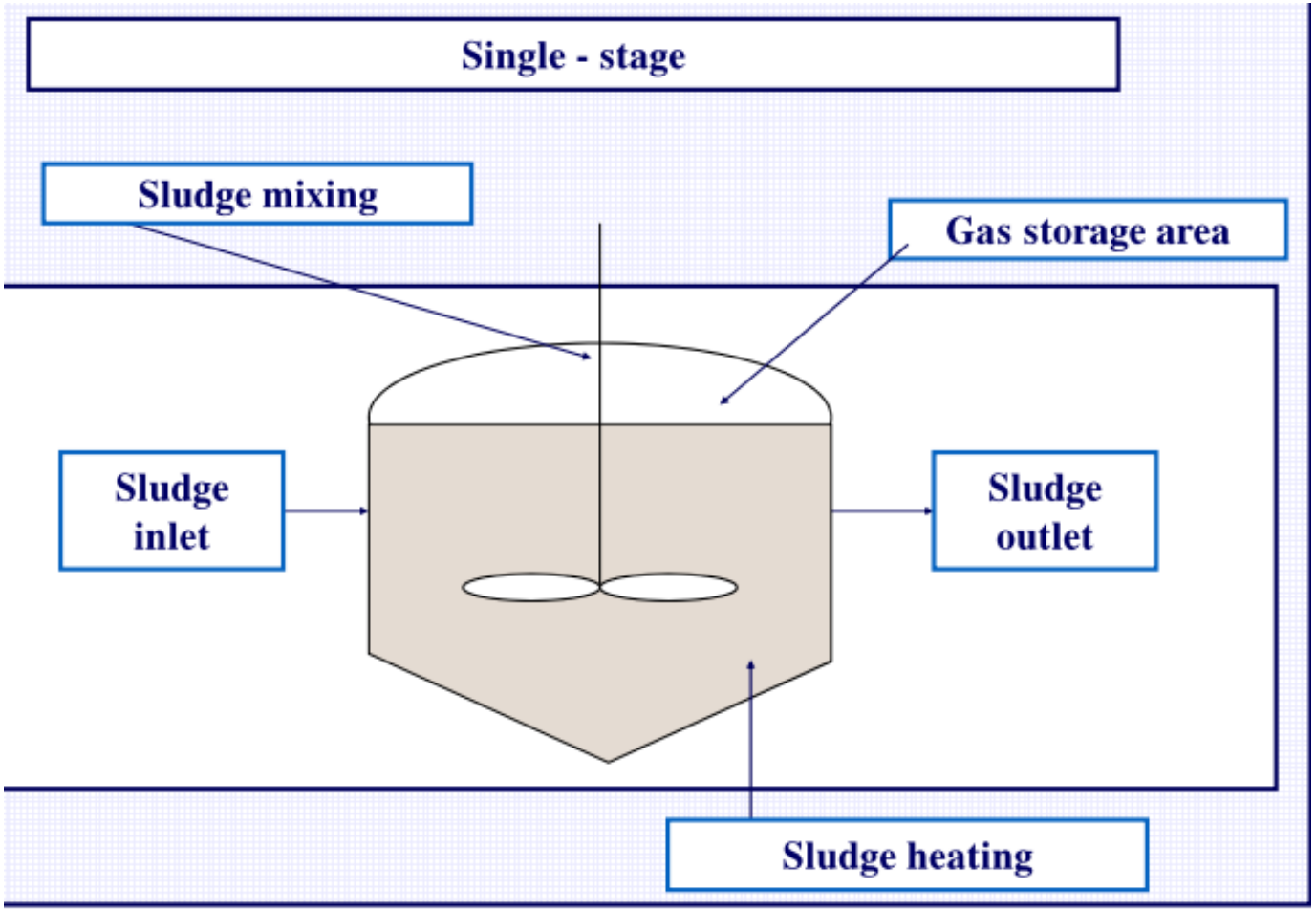
mesophilic vs. thermophilic

- **Mesophilic digestion**
  - **Characteristics**
    - Digestion takes place at a temperature of between 35 and 37°C.
    - Contact time in the digester ranges from 16 to 23 days
    - Sludge must be pre-thickened
- **Thermophilic digestion**
  - Characteristics
    - Digestion takes place at a temperature of between 50 and 60°C.
    - Contact time in the digester is from 8 to 12 days
    - Sludge must be pre-thickened

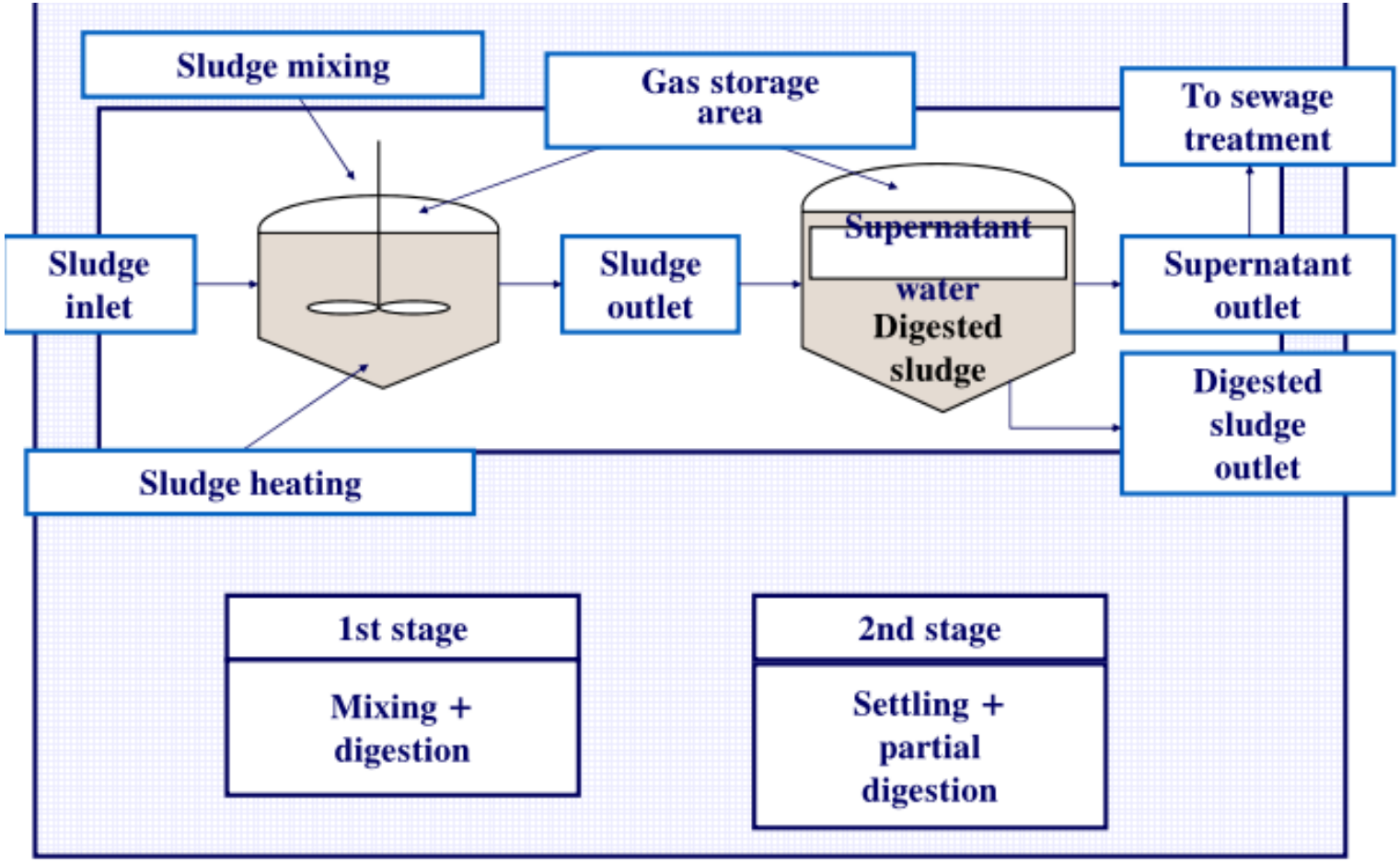
Sludge volume reduction

VSS reduction	
Primary sludge	50 - 60 %
Biological sludge	20 - 50 %
Primary + Biological sludge	40 - 60 %

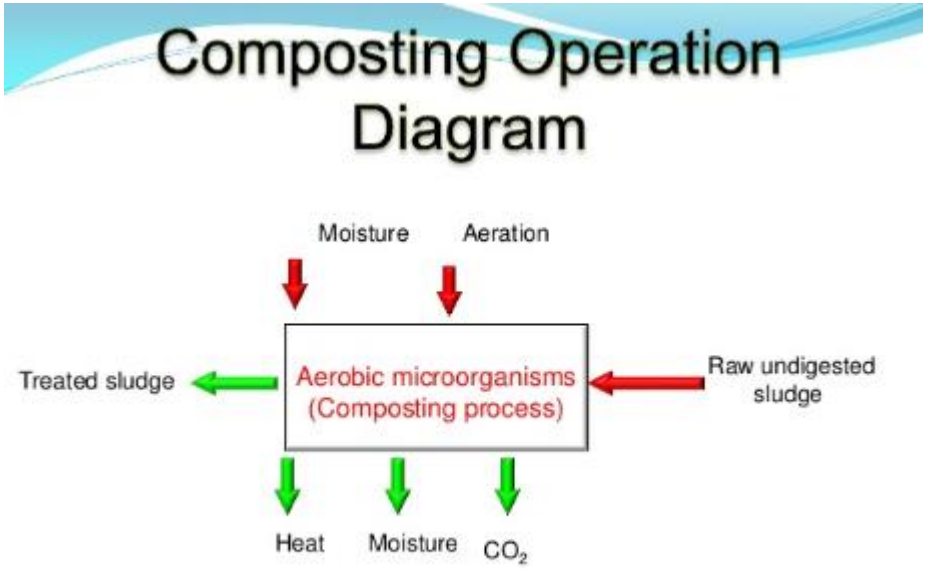
Single stage digester



Two stage digestion



composting

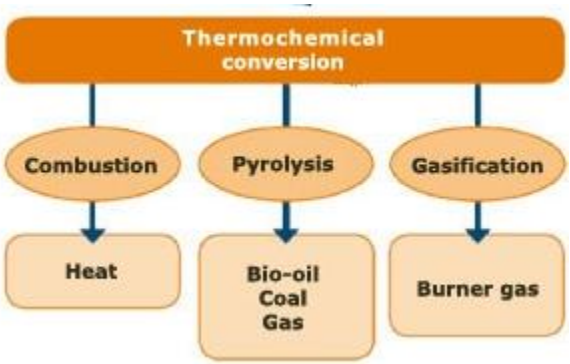

Composting Operation Diagram
Moisture
Aeration
Treated sludge
Aerobic microorganisms (Composting process)
Raw undigested sludge
Heat
Moisture
CO_2

composting

composting

compost

(thermal treatment) more than 500 c



Combustion (incineration)

- Incineration involves the combustion of organic materials (abundance of oxygen) to ash, flue gases, particulates, and heat that can be used to generate electricity, reducing the volume of waste by 95-96%,

gasification

- Solid waste gasification is the partial oxidation of waste fuel in the presence of an oxidant of lower amount than that required for the stoichiometric combustion. The gasification process breaks down the sludge to useful byproducts that contain a significant amount of partially primarily a mixture of carbon monoxide, hydrogen called syngas and carbon dioxide.

Pyrolysis

- Pyrolysis of solid waste fuel is defined as a thermo-chemical decomposition of waste fuel at elevated temperatures, in the absence of air and it converts sludge into gas (syngas), liquid (tar) and solid products (char). The main goal of pyrolysis is to increase thermal decomposition of solid waste to gases and condensed phases. The amount of useful products from pyrolysis process (CO, H_2 , CH_4 and other hydrocarbons) and their proportion depends entirely on the pyrolysis temperature and the rate of heating

landfilling