BIOLOGICAL WASTEWATER TREATMENT

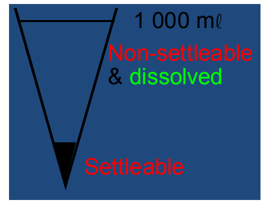
PART 2 - WASTEWATER CHARACTERIZATION

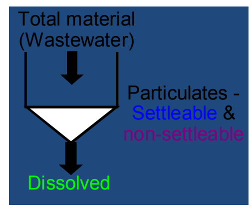
PHYSICAL CHARACTERIZATION OF WASTEWATER

- The constituents of wastewater comprise
  - Organic and inorganic,
  - Biodegradable and unbiodegradable,
  - Settleable, non-settleable and dissolved,
- …compounds.
- We need to measure the COD, TKN and TP concentrations of each

SOME DEFINITIONS

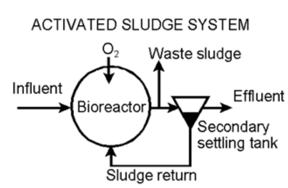
- Settleable (particulate) – can settle out in < 2h when not mixed (Settleability test)
- Non-settleable (particulate) – does not settle out in < 2h when not mixed.
- Dissolved (soluble) – passes through a 0.45 μm membrane filter (Filtration test).





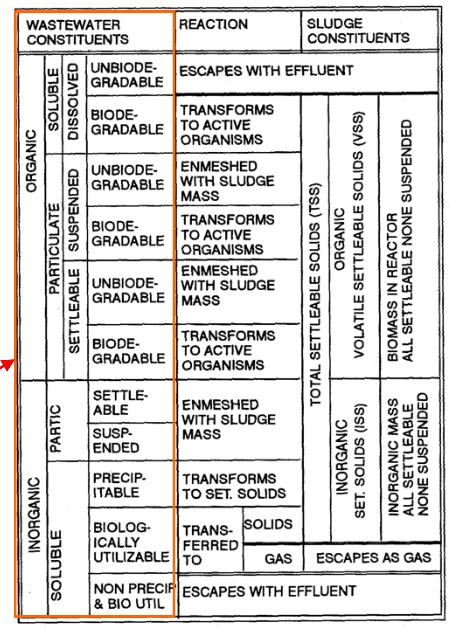
PHYSICAL CHARACTERISTICS OF ACTIVATED SLUDGE

- The constituents of activated also comprise
  - Organic and inorganic,
  - Biodegradable and unbiodegradable,
  - Settleable, non-settleable and dissolved,
- …compounds.
- BUT non-settleable content is negligibly small!



FATE OF WASTEWATER CONSTITUENTS IN THE ACTIVATED SLUDGE SYSTEM

Waste-water charac-teristics



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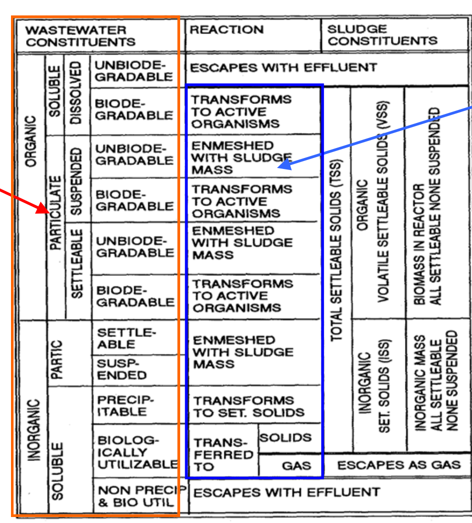
PROCESS REACTIONS

Waste-water charac-teristics



Process reactions

Organics are degraded by ordinary heterotrophic organisms (OHOs) group.

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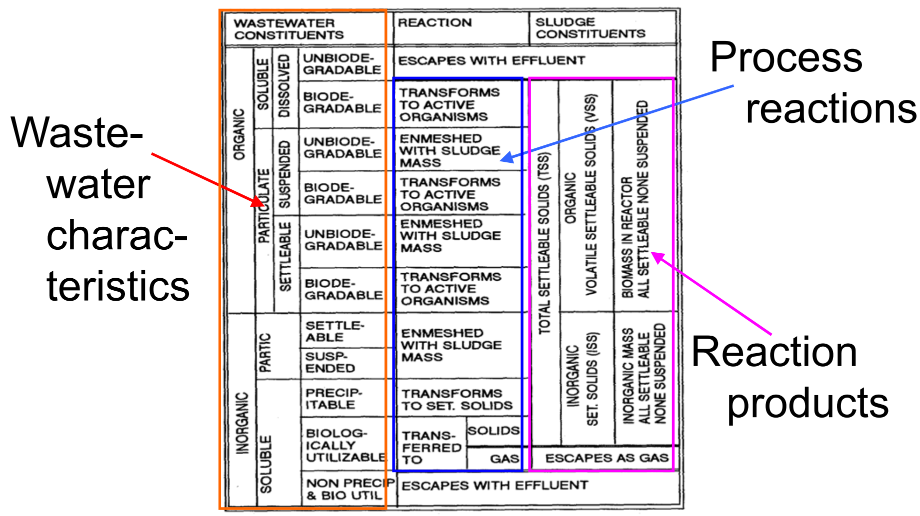
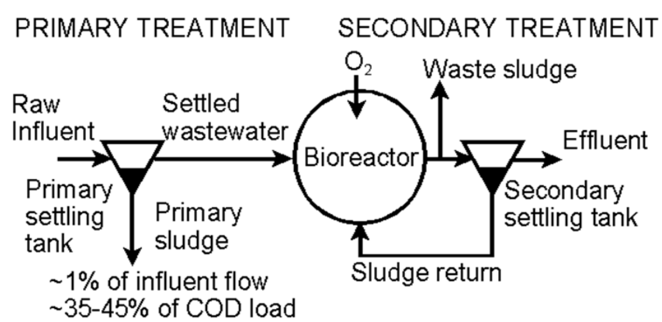
PROCESS REACTIONS



PRIMARY TREATMENT

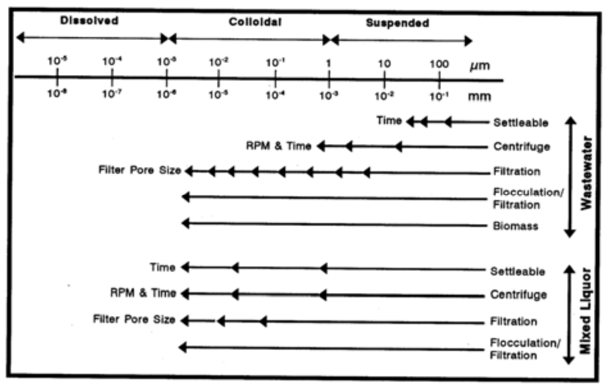


- Irrespective of treating RAW or SETTLED WW all ACTIVATED SLUDGE in the reactor is settleable, i.e. no (negligible) non-settleable solids in effluent; all settles out <2h.

PHYSICAL CHARACTER-IZATION TESTS

- Organic and inorganic material in wastewater characterized on basis of particle size
  - Dissolved
  - Settleable

- Effect of different solid-liquid separation methods



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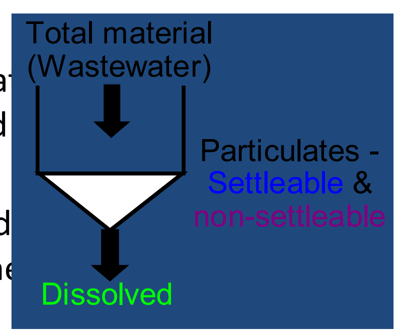
FILTRATION TEST

- The COD, TKN, FSA, TP, OP, NO_3^- (whatever else) of liquid passing through filter membrane (called filtrate) is measured.
- Depending on pore size, the filtra[te] concentrations give the dissolved concentrations.
- The difference between Total and dissolved concentrations gives the particulate concs.



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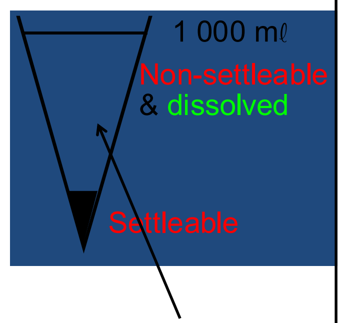
SEDIMENTATION TEST

- Uses Imhoff cone (1ℓ)
- Estimate volume of settled solids at bottom of cone after 2h, e.g. 15mℓ/ℓ settleable solids.
- Difference between supernatant concs and dissolved concs are the non-settleable concs.



- Has approx concentrations of settled WW

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WASTEWATER SOLIDS TEST METHOD (1)

Total (settleable + non-settleable) solids using ASHLESS filter paper……

- (1) Dry filter paper at 105°C for ½h.
- (2) Weigh (Mass 1)
- (3) Filter 1 ℓ raw WW through filter paper.
- (4) After most water has run through, place filter paper in crucible and dry at 105°C for >12h.

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WASTEWATER SOLIDS TEST METHOD (2)

- (5) Cool in desiccator and weigh (Mass 2)
- Mass 2 – Mass 1 (in mg) = TSS in mg/l
- (6) Weigh clean, dry crucible (Mass 3)
- (7) Place filter paper with solids in crucible and incinerate at 600^{o}C for 20 min.
- (8) Cool in desiccator and weigh (Mass 4).
- Mass 4 – Mass 3 (in mg) = ISS in mg/l
- VSS = TSS – ISS (mgISS/l)

WASTEWATER SOLIDS TEST METHOD (3)

- The settleable solids of raw wastewater can be measured the same way except for step (3). In this step…….
- (3a) Allow raw WW to settle for 1h in Imhoff cone,
- (3b) After carefully decanting supernatant from Imhoff cone, wash remaining liquid and settled solids into filter paper with distilled water.

SETTLEABLE SOLIDS TESTS

- The settled solids volume (ml/l) read on the Imhoff Cone Test can be converted to concentration (mg/l) with settleable solids test result, e.g.
- 15 ml/l settled solids volume gave a concentration of 380 mgTSetS/l.
- From many tests, it has been found that 1 ml/l is approx equivalent ~25 mgTsetS/l.

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SETTLEABLE SOLIDS TESTS

- Settleable solids tests are done on raw WW to estimate mass of primary sludge that settles in primary settling tanks (PST).
- The non-settleable solids concentration can be determined in two ways….
  - (1) Measure TSS and VSS with method above, which gives Settleable + non-settleable.
  - (2) Applying TSS and VSS on supernatant of cone test, which gives non-settleable only.

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WW PHYSICAL TESTS

- The filtration and sedimentation tests can only distinguish between the physical characteristics of material in the WW – dissolved, non-settleable, settleable and organic and inorganic.
- These tests cannot distinguish between biodegradable and unbiodegradable organics – this can only be done biologically in an activated sludge system (more later).

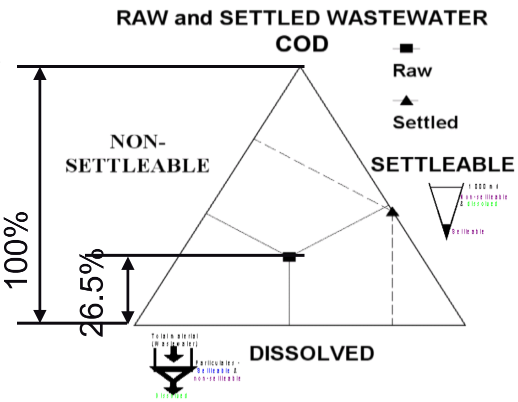
WASTEWATER PHYSICAL CHARACTERISTICS

- Settleable COD = 750-450 = 300; %=300/750=40%
- Non-settleable = 450-199 = 251; %=251/750=33.5%
- Dissolved= 199; %=199/750=26.5%
- Plot % settleable, % non-settleable and % dissolved in equilateral triangle.

PHYSICAL CHARACTERIZATION TA		
Parameter	COD	COD
Units	mgCOD/l	%
Raw WW	750	
Settled	450	
0.45 Filt	199	
Settleable	300	
Non-Set	251	
Dissolved	199	
RAW WW	Conc	%
Settleable	300	40.0
Non-Set	251	33.5
Dissolved	199	26.5
Particulate	551	73.5
SETTLED		
Settleable	0	0.0
Non-Set	251	55.8
Dissolved	199	44.2
Particulate	251	55.8
Prim Sludge	300	40.0

WASTEWATER PHYSICAL CHARACTERISTICS

- Plot % settleable, % non-settleable and % dissolved in equilateral triangle
- e.g. for dissolved, if 100%=10cm,then 26.5%=2.65cm up from base (0%) to apex (100%).



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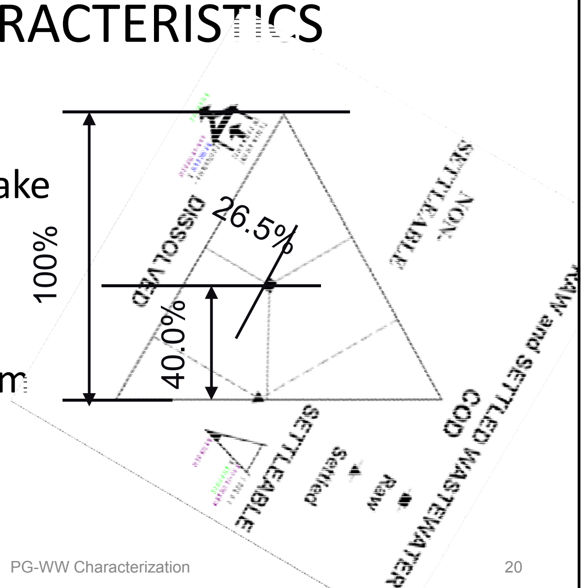
WASTEWATER PHYSICAL CHARACTERISTICS

- Do same for settleable: So
- Turn triangle to make settleable base, then…
- 100%=10cm,so 40%=4.0cm up from base (0%) to apex (100%).



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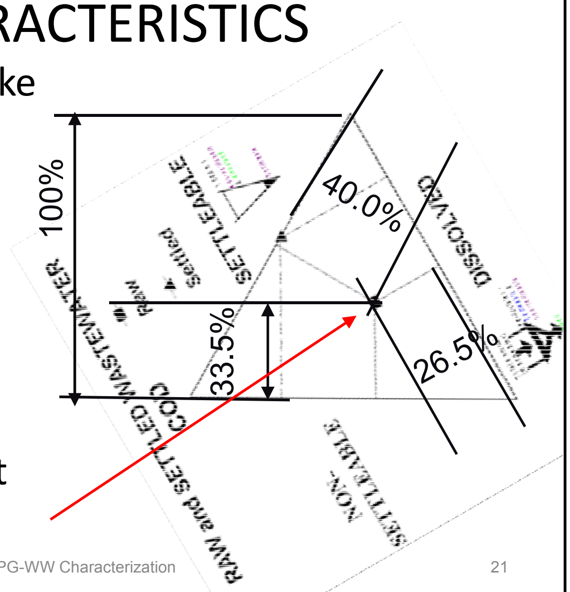
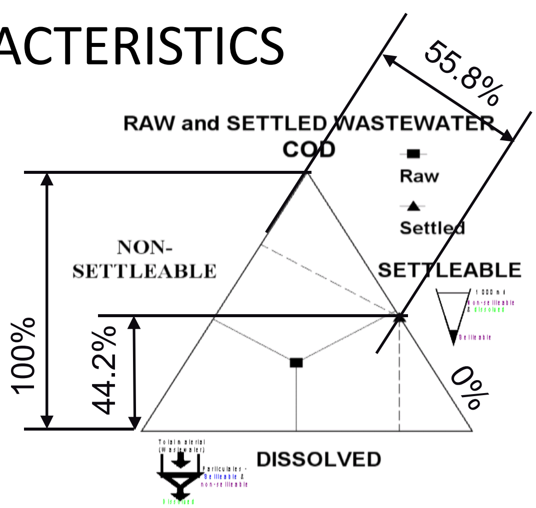
WASTEWATER PHYSICAL CHARACTERISTICS

- Turn triangle to make settleable base, then…
- 100%=10cm,so 33.5%=3.35cm up from base (0%) to apex (100%).
- Line must pass through same point



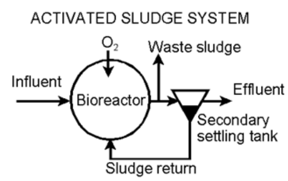
WASTEWATER PHYSICAL CHARACTERISTICS

- Repeat for settled Wastewater COD..
- Settleable=0%, non-settle=55.8% dissolved = 44.2%.
- Can do physical char triangles like this for TOC, TKN, FSA, TP and OP.



SOLIDS TESTS ON REACTOR

- Solids tests on activated sludge (AS) reactor contents give quantitative measure of solids in reactor - TSS (Total), VSS (organic) and ISS (inorganic).



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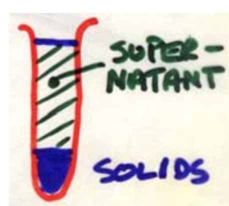
TSS - VSS TEST METHOD

- (1) Take measured volume of AS (100ml)
- (2) Centrifuge sample at >3000 rpm for 20 min.



- (3) Carefully decant off supernatant (keep for other tests such as FSA, nitrate, etc.)
- (4) Wash solids to clean dry crucible with distilled water. Mass of Crucible = Mass 1, say 28.1378g.

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TSS - VSS TEST METHOD

- Drying in oven at 105°C for >12h.
- Place in desiccator to cool and weigh, Mass 2 = mass of crucible + dried solids. Say 28.6531g
- Incinerate at 600°C for 20 min.
- Place in desiccator to cool and weigh, Mass 3 = mass of crucible + non-combustible (inorganic) solids. Say 28.2668g

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TSS – VSS CALCULATION

$$TSS = \frac{(\text{MASS 2} - \text{MASS 1})\,g}{\text{SAMPLE VOLUME}\ ml} \cdot 1000\,\frac{mg}{g} \cdot 1000\,\frac{ml}{\ell}$$

$$= (28{,}6531 - 28{,}1378) \cdot 10^6/100 = 5153\ mg\,TSS/\ell$$

$$VSS = \frac{(\text{MASS 2} - \text{MASS 3})\,g}{\text{SAMPLE VOLUME}\ ml} \cdot 1000\,\frac{mg}{g} \cdot 1000\,\frac{ml}{\ell}$$

$$= (28{,}6531 - 28{,}2668) \cdot 10^6/100 = 3863\ mg\,VSS/\ell$$

$$ISS = \frac{(\text{MASS 3} - \text{MASS 1})\,g}{\text{SAMPLE VOLUME}\ ml} \cdot 1000\,\frac{mg}{g} \cdot 1000\,\frac{ml}{\ell}$$

$$= (28{,}2668 - 28{,}1378) \cdot 10^6/100 = 1290\ mg\,ISS/\ell$$

$$\text{OR} = TSS - VSS = 5153 - 3863 = 1290\ mg\,ISS/\ell$$

$$\%\ \text{VOLATILE (OR ORGANIC)} = \frac{3863}{5153} \cdot 100 = 75\%\ \frac{VSS}{TSS}$$

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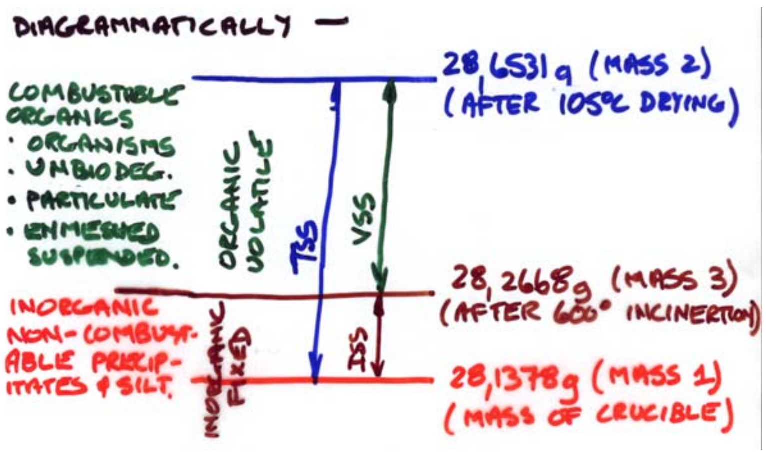
TSS – VSS CALCULATION



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COD/VSS RATIO OF AS (1)

- The VSS (organics) in AS reactor comprises 3 types of organics
  - (1) live organisms (X_{BH})
  - (2) unbiodegradable endogenous residue generated by death of organisms (X_{EH})
  - (3) unbiodegradable particulate organics from influent wastewater (X_I).
- If we accept that the composition of these organics is the same and approximated by $C_5H_7O_2N$, then……

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COD/VSS RATIO OF AS (2)

Can calculate theoretical COD/VSS (f_{cv})

$$C_5H_7O_2N + 8H_2O \rightarrow 5CO_2 + NH_3 + 20e^- + 20H^+$$

$$20H^+ + 20e^- + 5O_2 \rightarrow 10\,H_2O$$

$$\underbrace{C_5H_7O_2N}_{\substack{5.12+7+2.16+14 \\ =113\text{g organisms}}} + \underbrace{5O_2}_{5.2.16=160\text{g oxygen}} \rightarrow 5CO_2 + 2H_2O + NH_3$$

- So COD/VSS ratio (f_{cv}) = 160/113=1.42 gCOD/gVSS
- Experimentally we measure 1.48 gCOD/gVSS

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COD/VSS RATIO OF AS (3)

- From the AS steady state model, we know that the proportions of (1) live organisms, (2) endogenous residue and (3) unbiodegradable particulate organics from the influent in the VSS change depending on how reactor is operated (i.e. high or low sludge wastage flow rate – more later), yet the COD/VSS ratio does not change much – it remains at around 1.48.

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COD/VSS RATIO OF AS (3)

- We conclude for this that the composition, i.e. the x, y, z and a values in $C_xH_yO_zN_a$ of the 3 different constituents of AS VSS are approximately similar, despite their obvious differences (live organisms, unbiodegradable).
- So we can calculate the VSS for the influent unbiodegradable particulate organics from its COD value and *vice versa*.

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VSS & COD TESTS on AS

- The VSS and COD tests on the AS solids cannot distinguish between biodegradable (live) and unbiodegradable organics.
- The physical separation tests …
  - (1) filtration can only distinguish between dissolved and particulate organics, and
  - (2) sedimentation can only distinguish between settleable and non-settleable organics.

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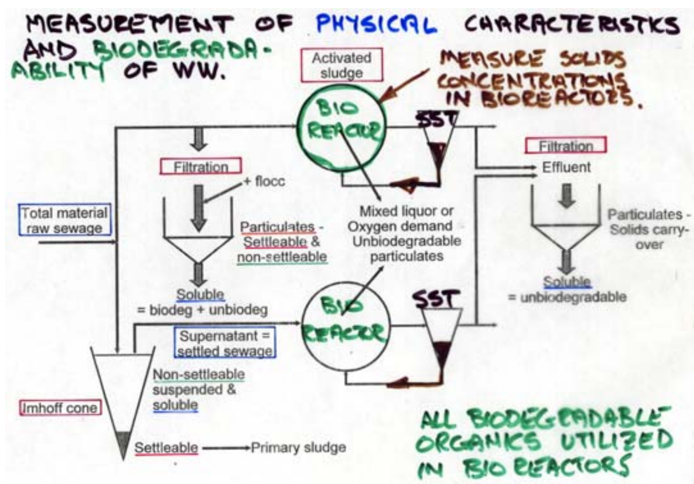
VSS & COD TESTS on AS

- The VSS and COD tests on the AS solids cannot distinguish between biodegradable (live) and unbiodegradable organics.
- Physical separation (filtration) can only distinguish between dissolved and particulate organics.

BIODEGRADABLE ORGANICS in WW

- The only way the dissolved and particulate organics can be separated into their biodegradable and unbiodegradable parts is by treating the WW in an AS system and measuring.....
  - (1) COD concentration in effluent = unbiodegradable soluble, $S_{use} = S_{usi}$, and
  - (2) VSS concentration and oxygen utilization rate in reactor – the higher the VSS and lower the OUR, the higher the unbio. COD

BIODEGRADABILTY OF ORGANICS



Soluble biodegradable organics important for biological N and P removal.

Unbiodegrad-able particulate organics can only be determined by measuring VSS and OUR in reactors at steady state.

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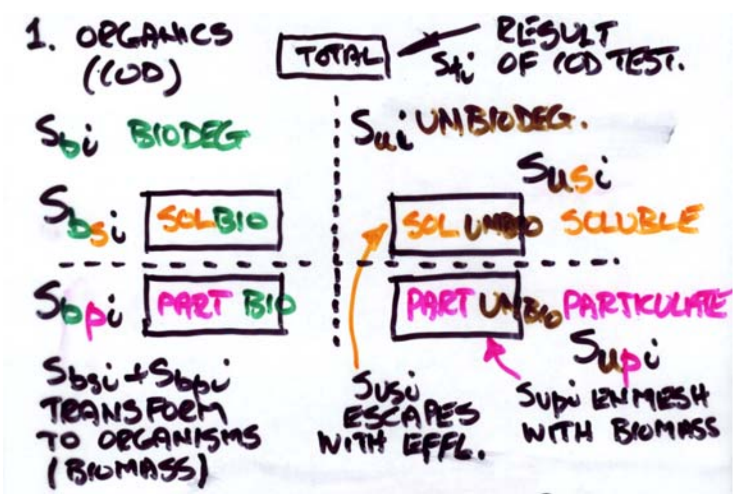
WW COD FRACTIONATION



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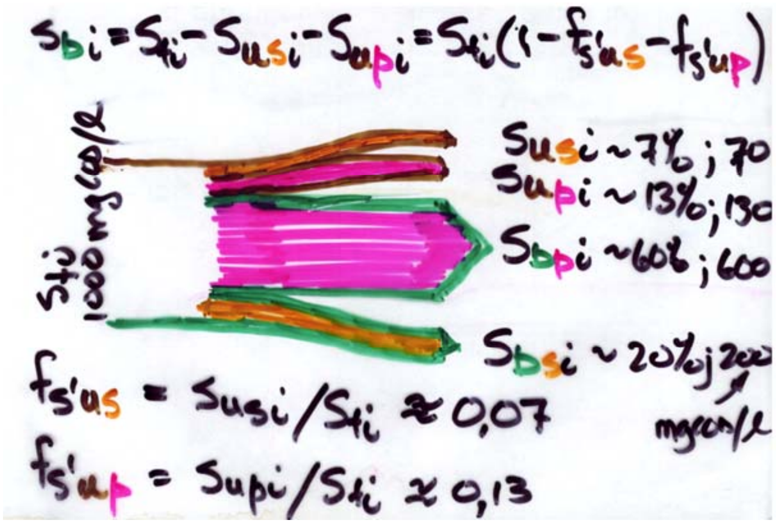
WW COD FRACTIONATION



Example:

Raw WW

S_{ti} = 1000 mgCOD/l

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WW COD FRACTIONATION

- $f_{S'us}$ = Influent unbiodegradable soluble COD fraction = S_{usi}/S_{ti}
- $f_{S'up}$ = Influent unbiodegradable particulate COD fraction = S_{upi}/S_{ti}
- X_{Ii} is unbiodegradable particulate organics conc in terms of VSS, i.e.
- $X_{Ii} = S_{upi}/f_{cv} = f_{S'up}\, S_{ti}/f_{cv}$ mgVSS/l

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UNBIO. COD FRACTIONS

Parameter	Raw WW	Settled WW
Unbiodegradable Soluble ($f_{S'us}$)	0.04 – 0.08	0.08 – 0.12
Unbiodegradable Particulate ($f_{S'up}$)	0.10 – 0.15	0.00 – 0.06
VSS/TSS ratio of Reactor Solids (f_i)*	0.75 – 0.83	0.80 - 0.90

- *The VSS/TSS ratio varies depending on the influent inorganic suspended solids (ISS) concentration (X_{IOi})…
  - If high (20-30mgISS/l), then f_i is low
  - If low (5-10mgISS/l), then f_i is high

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BIODEG. COD FRACTIONS

- $S_{bi} = S_{ti} - S_{usi} – S_{upi} = S_{ti} (1-f_{S'us}-f_{S'up})$.
- $S_{bi} = S_{bsi} + S_{bpi}$ and
- $S_{bsi} = f_{Sb's} S_{bi}$ and $S_{bpi} = (1-f_{Sb's}) S_{bi}$
  – Where $f_{Sb's}$ = fraction of influent biodegradable COD that is bio. soluble.
- Also, $S_{bsi} = f_{S'bs} S_{ti}$
  – Where $f_{S'bs}$ = fraction of influent total COD that is biodegradable soluble.

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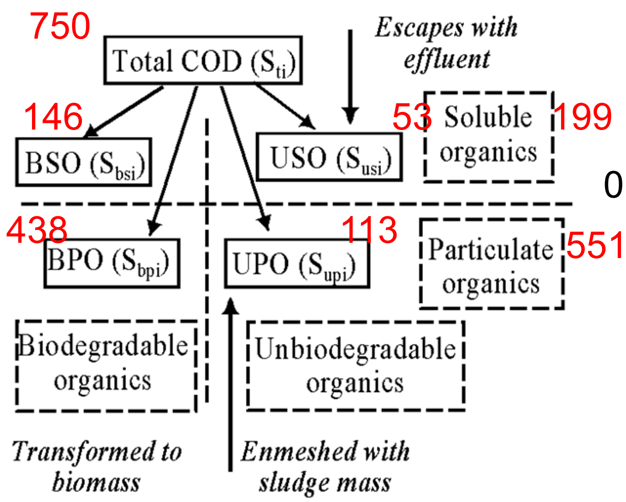
EXAMPLE WW: COD - RAW



Units – mgCOD/L

0.45μ filtered -

Sol COD =199

$f_{S'us} = S_{usi}/S_{ti}$
$= 0.07$

$f_{S'up} = S_{upi}/S_{ti}$
$= 0.15$

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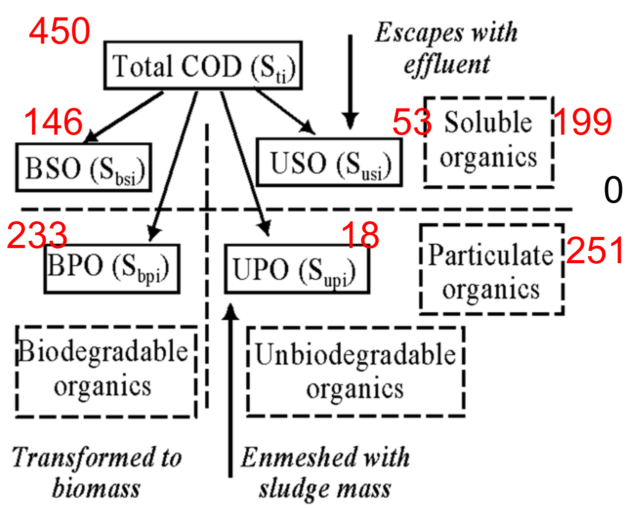
EXAMPLE WW: COD - SETTLED



Units – mgCOD/L

0.45μ filtered -

Sol COD =199

$f_{S'us} = S_{usi}/S_{ti}$
$= 0.113$

$f_{S'up} = S_{upi}/S_{ti}$
$= 0.04$

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INFLUENT NITROGEN

- Influent N compounds (reduced) comprise Free (NH_3) and Saline (NH_4^+) Ammonia (FSA) and Organic Nitrogen (OrgN), which is N bound in organics - proteins.
- Two tests measure these –
  - FSA test – measures ammonia
  - TKN test – measures FSA + OrgN

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REDUCED N TEST METHODS – TKN & FSA

- (1) Acid digest sample. This breaks down all organics and releases N in proteins as ammonia.
- (2) Raise pH > 10 and do FSA test.
- (3) TKN = 14x1000xN_{acid} x $V_{titrate}$/V_{sample}.
- (4) TKN = 14000x0.001x24.3ml/10ml = 34.0 mgTKN-N/l.

For TKN Test – all 4 steps

For FSA Test – Steps 2-4 only

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OXIDIZED N (NO_3, NO_2)

- Oxidized N, like NO_3 and NO_2, are NOT measured in FSA and TKN tests.
- WW usually have zero influent NO_3 due to denitrification in sewer (N_{ni} = 0).

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ORGANIC N (OrgN)

- Organic N (N_{oi}) = TKN (N_{ti}) – FSA (N_{ai})
- $N_{oi} = N_{ti} - N_{ai}$ mgOrgN-N/l.
- Because organic N is N bound in organics, it has soluble, particulate, biodegradable and unbiodegradable constituents.
- So OrgN fractionates exactly like COD.
- In fact, the OrgN is the N content of the same organics measured as COD.

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S_{upi}, X_{Ii}, N_{oupi} & P_{oupi} LINKS

- Say UPO can be represented by $C_5H_7O_2N_{0.8}P_{0.09}$
- Then COD is: $C_5H_7O_2N_{0.8}P_{0.09}$ +8.36H_2O= 5CO_2+0.8NH_3+0.09H_3PO_4+21.15(e^-+H^+)
- In general EDC = γ_s = 4x+y-2z-3a+5b e^-/mol if composition is $C_xH_yO_zN_aP_b$
- So COD=32/4γ_s=8x21.15=169.2gCOD/mol.
- VSS=60+7+32+0.8x14+0.09x31=113g/mol
- So f_{cv}= 169.2/113=1.497 gCOD/gVSS

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S_{upi}, X_{Ii}, N_{oupi} & P_{oupi} LINKS

- The N/VSS mass ratio (fn) is found from the N content of the organics (UPO)….
- f_n (gN/gVSS)=0.8x14/113=0.099 or
- N/COD= 0.8x14/169.2=0.066gN/gCOD

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COMPOSITION OF ORGANIC TYPES (1)

- The same principle applies also to the BPO and other organic types (USO, BSO)
- But composition of each type is different.
- Can be represented by $C_XH_YO_ZN_AP_B$ or $C_{fc/12}H_{fh/1}O_{fo/16}N_{fn/14}P_{fp/31}$ where $X=f_c/12$, etc.
- And f_c, f_h, f_o, f_n and f_p are the mass ratios gC/g, gH/g, gO/g, gN/g and gP/g and determined by measurement.

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COMPOSITION OF ORGANIC TYPES

- The important thing to understand is that COD, TOC, OrgN, OrgP are characteristics of the same organic compounds grouped into measurable types (BPO, UPO, BSO and USO) and f_{cv}, f_c, f_n and f_p are the measured mass ratios of these groups .

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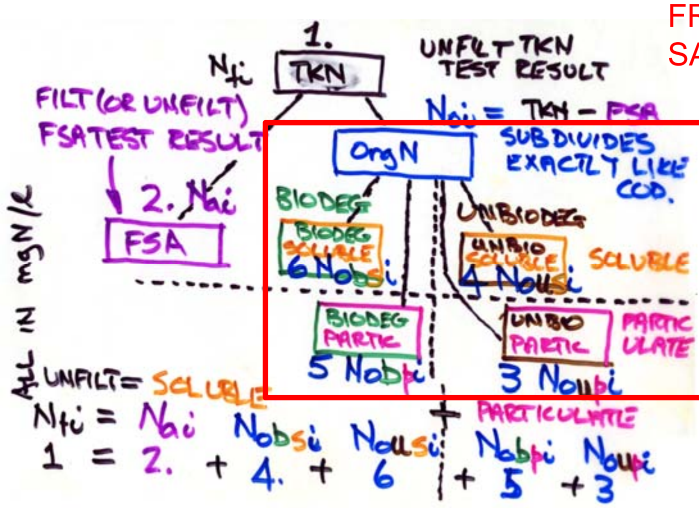
TKN FRACTIONATION



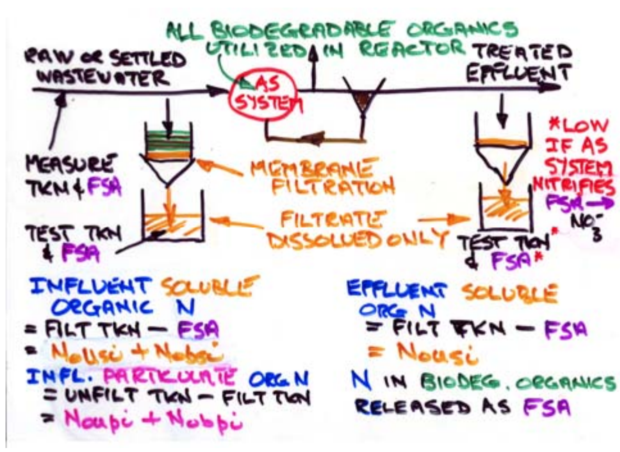
FRACTIONATES SAME AS COD

(1) Unfiltered TKN – Filtered TKN = Particulate OrgN = N_{obpi} + N_{oupi}

(2) Filtered influent TKN = FSA + dissolved OrgN = N_{ai} + N_{obsi} + N_{ousi}.

(3) Effluent OrgN is unbiodegradable soluble OrgN (N_{ousi}) = Effl TKN – Effl FSA.

MEASUREMENT OF TKN FRACTIONS

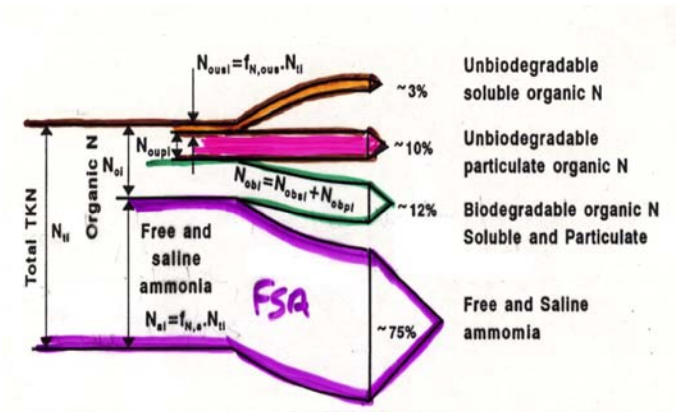


(1) Influent biodeg. OrgN, both soluble and particulate, released as FSA in the breakdown of biodegradable organics in AS reactor.

(2) Effluent OrgN is unbiodegradable soluble OrgN (Nousi) = Effl TKN – Effl FSA.

(3) Unbiodegradable particulate OrgN is found from N content of unbiodegradable particulate COD.

WW TKN COMPOSITION



Raw Wastewater

(1) $f_{N'ous}$ = fraction of N that is organic unbiodegradable and soluble = N_{ousi}/N_{ti} = 0.03.

(2) $f_{N'a}$ = fraction of N that is ammonia = N_{ai}/N_{ti} = 0.75.

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TKN FRACTIONATION

- $N_{ai} = f_{N'a}\, N_{ti}$ (or FSA directly measured)
- $N_{oi} = N_{ti} - N_{ai}$ (OrgN = TKN – FSA)
- $N_{ousi} = f_{N'ous}\, N_{ti}$ (or Filt Effl OrgN=Effl TKN-FSA)
- $N_{oupi} = f_n X_{Ii} = f_n f_{S'up} S_{ti}/f_{cv}$
- …is N content of UPO!)
- $N_{obi} = N_{oi} - N_{ousi} - N_{oupi}$
- N_{obsi} = FiltTKN-N_{ai}-N_{ousi}
- = Filt OrgN-N_{ousi}
- $N_{obpi} = N_{obi} - N_{obsi}$

WW TKN Fractions

	Raw	Settled
$f_{N'a}$	0.7 - 0.8	0.75 - 0.85
$f_{N'ous}$	0.02 - 0.04	0.03 – 0.05

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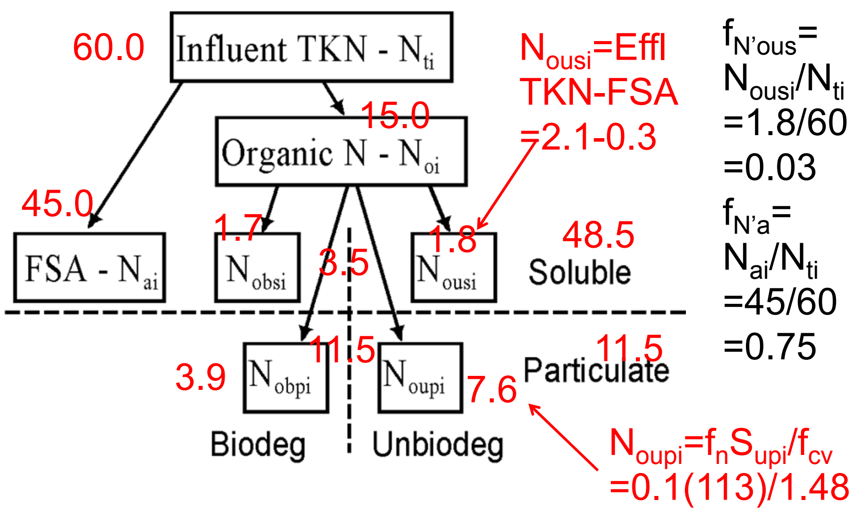
EXAMPLE WW: TKN - Raw



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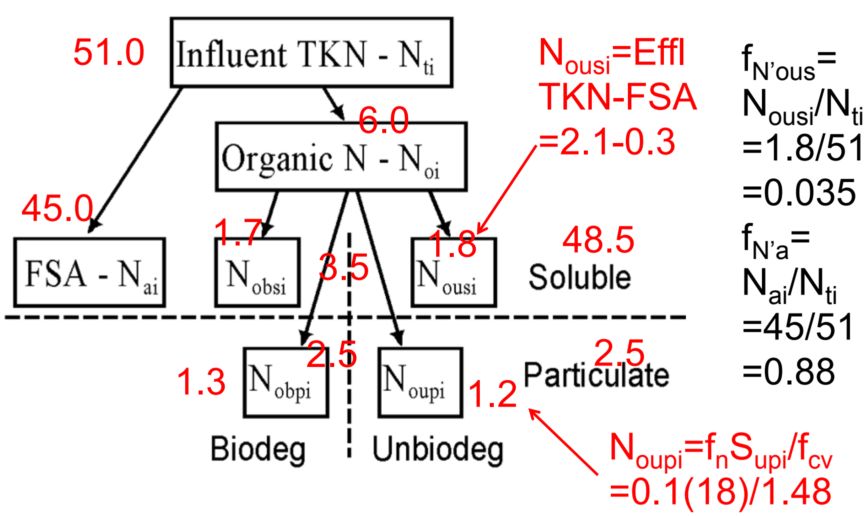
EXAMPLE WW: TKN - Settled



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INFLUENT PHOSPHORUS

- Influent P compounds comprise Ortho-phosphate (OP or inorganic P = H_3PO_4 + $H_2PO_4^-$ + HPO_4^{2-} +PO_4^{3-}) and Organic P (OrgP), which is P bound in organics.
- Two tests measure these –
  - OP test – measures ortho-phosphate
  - TP test – measures OP and OrgP

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TOTAL P and ORTHO-P TEST METHODS – TP & OP

- (1) Acid digest sample. This breaks down all organics and releases P in organics as ortho-P.
- (2) Test for OP.

For TP Test – both steps

For OP Test – Step 2 only

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ORGANIC P (OrgP)

- Organic P (P_{oi}) = TP (P_{ti}) – OP (P_{si})
- $P_{oi} = P_{ti} - P_{si}$ mgOrgP-P/l.
- Because organic P is P bound in organics, it has soluble, particulate, biodegradable and unbiodegradable constituents.
- So OrgP fractionates exactly like COD.
- In fact, the OrgP is the P content of the same organics measured as COD.

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ORGANIC P (OrgP)

- Organic P (P_{oi}) fractionates exactly the same as OrgN and uses same subscripts.
  - P_{ousi} – unbiodegradable soluble (usually zero)
  - P_{oupi} – unbiodegradable particulate OrgP (determined from P content of UPO)
  - P_{obsi} – biodegradable soluble OrgP
  - P_{obpi} – biodegradable particulate OrgP
- Biodegradable OrgP is released as OP in reactor when biodegradable organics are broken down and add to influent OP.

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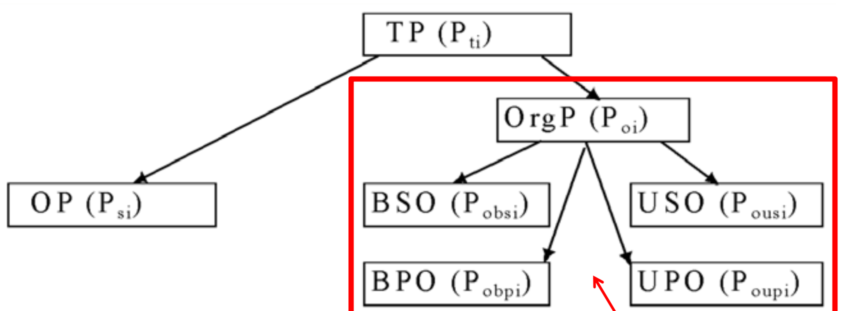
S_{upi}, X_{Ii}, N_{oupi} & P_{oupi} LINKS

- As before, say UPO can be represented by $C_5H_7O_2N_{0.8}P_{0.09}$
- Then similarly, P content of UPO is……
- f_p (gP/gVSS)=0.09x31/113=0.0247 or
- P/COD= 0.09x31/169.2=0.0165gP/gCOD.

Total P FRACTIONATION



- From experience, filtered effluent TP-OP≈0
- So P_{ousi} ≈0 and
- $P_{oupi}=f_p X_{Ii} = 0.025 S_{upi}/f_{cv}$.

FRACTIONATES SAME AS COD AND OrgN

S_{upi}, X_{Ii}, N_{oupi} & P_{oupi} LINKS

- So if total WW COD is 1000 mgCOD/l and $f_{S'up}$=0.15, then for this composition…
- UPO COD is 0.15x1000=150 mgCOD/l,
- UPO VSS (X_{Ii}) is 150/1.497=100mgVSS/l
- N_{oupi}=f_n X_{Ii} = 0.099x100=9.9 mgOrgN/l
- Or N_{oupi} = 0.066xS_{upi} = 9.9 mgOrgN/l.
- P_{oupi}=f_p X_{Ii} = 0.0247x100=2.47 mgOrgP/l
- Or P_{oupi} = 0.0165xS_{upi} = 2.47 mgOrgP/l.

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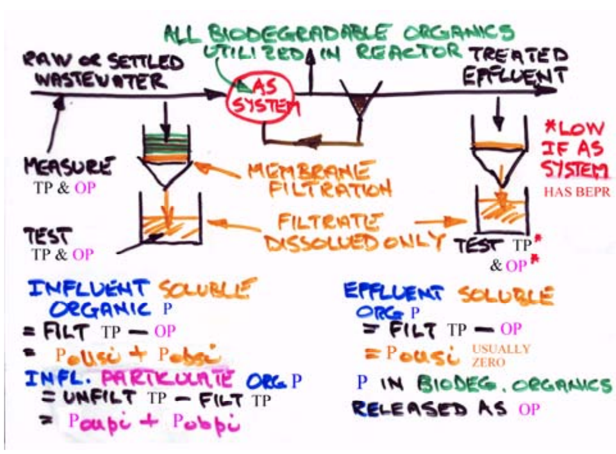
MEASUREMENT OF TP FRACTIONS



(1) Influent biodeg. OrgP, both soluble and particulate, released as OP in the breakdown of biodegradable organics in AS reactor.

(2) Effluent OrgP is unbiodegradable soluble OrgP (P_{ousi}) = Effl TP – Effl OP (≈0).

(3) Unbiodegradable particulate OrgP (P_{oupi}) is found from P content of UPO.

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TP FRACTIONATION

- $P_{si} = f_{P's}\, P_{ti}$ (or OP directly measured)
- $P_{oi} = P_{ti}-P_{si}$ (OrgP = TP – OP)
- $P_{ousi} = f_{P'ous}\, P_{ti}$ (or Filt Effl OrgP=Effl TP-OP, ≈0)
- $P_{oupi} = f_p\, X_{Ii} = f_p f_{S'up} S_{ti}/f_{cv}$
- …is P content of UPO!)
- $P_{obi} = P_{oi} - P_{ousi} - P_{oupi}$
- P_{obsi} = FiltTP-P_{si}-P_{ousi}
- = Filt OrgP-P_{ousi}
- $P_{obpi} = P_{obi}-P_{obsi}$

WW TP Fractions	Raw	Settled
$f_{P's}$	0.8 - 0.9	0.85 - 0.90
$f_{P'ous}$	0.00 - 0.01	0.00 – 0.02

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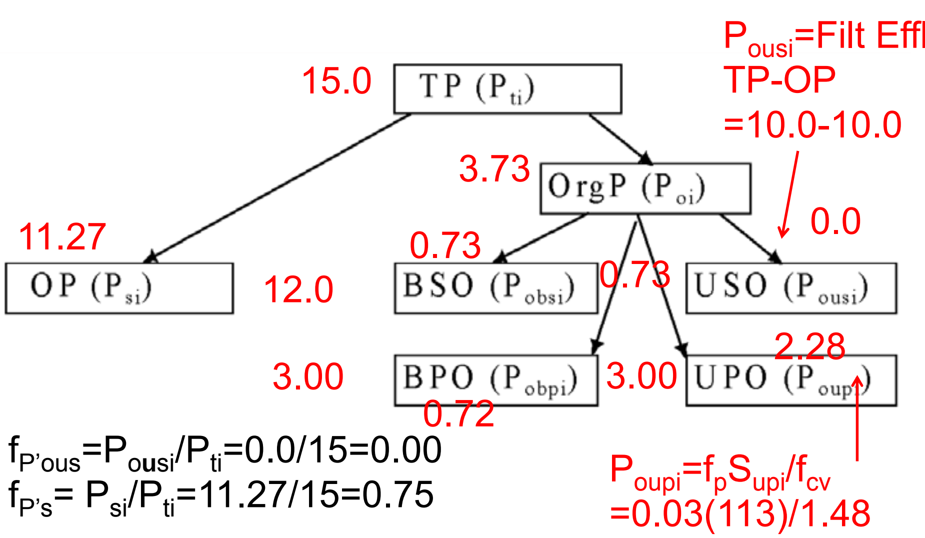
EXAMPLE WW: TP - Raw



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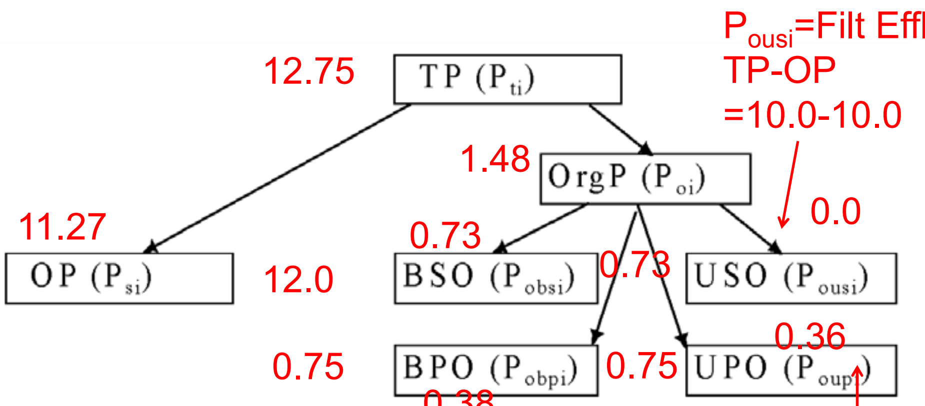
EXAMPLE WW: TP - Settled



$f_{P'ous}=P_{ousi}/P_{ti}$=0.0/12.75=0.00

$f_{P's}= P_{si}/P_{ti}$=11.27/12.75=0.884

$P_{oupi}=f_pS_{upi}/f_{cv}$
=0.03(18)/1.48

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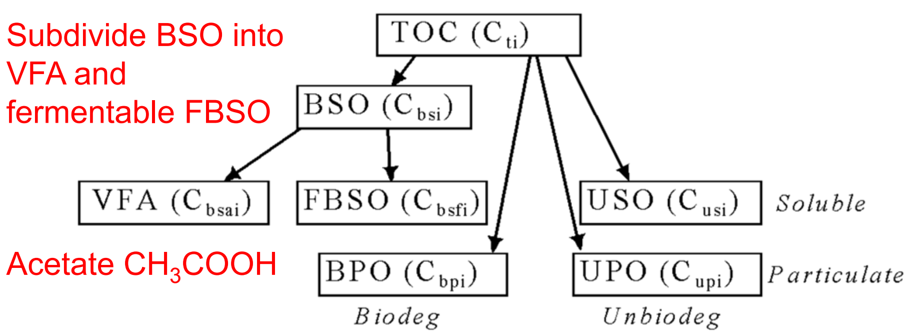
TOC FRACTIONATION



- Measure VFA (GC or 5 point titration).
- TOC of VFA = mgHAc/l x 24/60 mgC/l
- TOC of VFA = mgCOD/l x 24/64 mgC/l

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TOC FRACTIONATION

- TOC (C_{ti}) fractionates like COD and uses same subscripts.
  - C_{usi} = TOC of filtered AS system effluent.
  - So $f_{C'uso} = C_{usi} / (S_{usi} / f_{cv'uso})$ ($f_{cv'uso}$~1.42)
  - C_{bsfi} – fermentable biodeg soluble OrgC (TOC)
  - = C_{ti} (Filt TOC) – C_{bsai} - C_{usi}
  - C_{pi} (Partic TOC)= C_{ti} (Unfilt TOC) – C_{si} (Filt TOC)
  - $C_{upi} = f_{C'upo} X_{Ii}$ or $= f_{C'upo} (S_{upi} / f_{cv'upo})$($f_{cv'upo}$~1.48)
  - C_{bpi} – biodegradable particulate OrgC (TOC).

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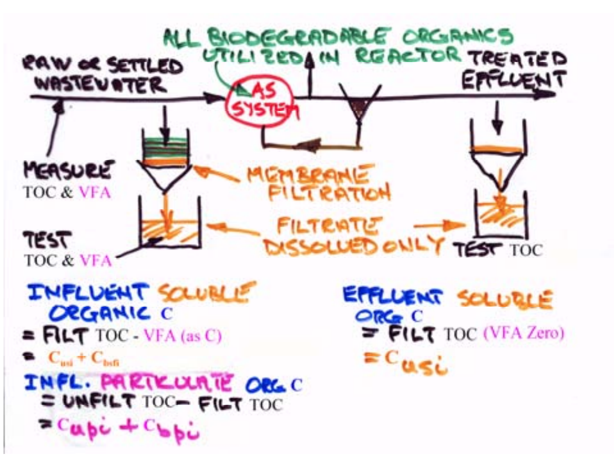
MEASUREMENT OF TOC FRACTIONS



(1) Effluent TOC is unbiodegradable soluble OrgC (C_{usi}) = Effl TOC (Effl VFA=0).

(2) Unbiodegradable particulate OrgC (C_{upi}) is found from C content of unbiodegradable particulate organics.

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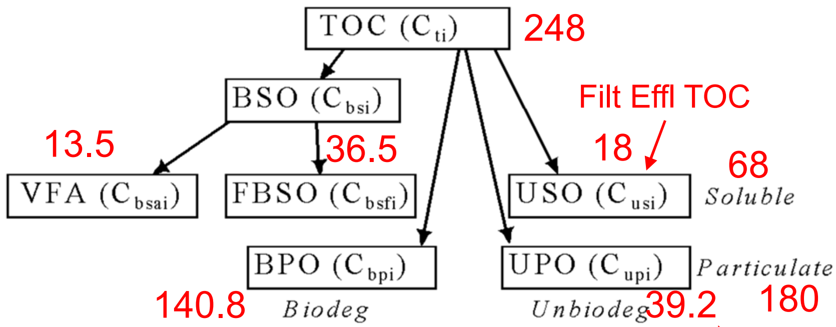
EXAMPLE WW: TOC - Raw



- TOC of VFA ($CH_3COOH \rightarrow$ 64gCOD/mol)
- C_{bsai} =36mgCOD/l x 24/64=13.5 mgC/l
- $C_{upi} = f_{C'upo}S_{upi}/f_{cv'upo}$=0.515(113)/1.48=39.2

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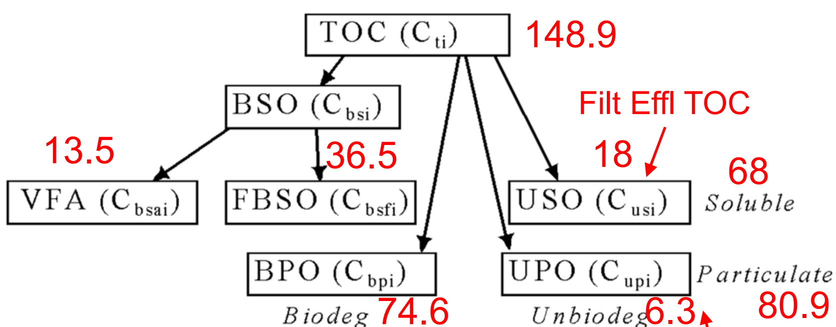
EXAMPLE WW: TOC - Settled



- Soluble conc same in Raw and Settled WW
- $C_{upi} = f_{C'upo}S_{upi}/f_{cv'upo}$=0.515(18)/1.48=6.3

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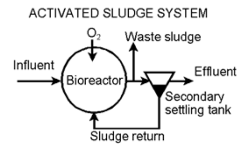
SUMMARY



- Influent WW organics need to be characterized into biodegradable and unbiodegradable and soluble and particulate organics because these behave differently in the AS reactor…
  - Unbiodegradable soluble exit with effluent.
  - Unbiodegradable particulate accumulate with solids in reactor and exit via waste sludge.
  - Biodegradable organics are broken down to form new biomass for which O_2 is required.

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