Aerobic Digestion,
or,
It’s a Bug eat Bug World

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Aerobic Digestion

- Continuation of the Activated Sludge Process
  - "Super" Extended Aeration
  - No food is added
  - Reduction of Volatile Solids through:
    - Endogenous Respiration
      - Bacterial Cells use their own protoplasm for energy
      - Some cells die and become food for others

Biological Chemistry

- BOD, Bug Food, Organic Pollution
  - Test of the organic strength of sewage
    - Organic- from plants and animals
      - Protein, carbohydrates, fats
    - Fecal matter, food scrapes, paper, industrial waste of plant or animal origin.

- Normal Bacteriological Respiration

$$BOD + BOD_{Bugs} + O_2 = \text{More } BOD_{Bugs} + CO_2 + H_20 + NH_3$$

Respiration / Oxidation

- Respiration
  - We call it breathing
  - Scientifically it is the release of energy
  - The Bugs want the energy in the BOD
    - Energy to live and grow
  - The Bugs are teeny tiny chemical factories
    - They split complex organic compounds into simple oxidized compounds.

Respiration / Oxidation

- Normal Bacteriological Respiration

$BOD + BOD_{Bugs} + O_2 = More\ BOD_{Bugs} + CO_2 + H_20 + NH_3$

Glucose

$C_6H_{12}O_6 + BOD_{Bugs} + O_2 = More\ BOD_{Bugs} + CO_2 + H_20$

Protein

$C_3H_7O_2N + BOD_{Bugs} + O_2 = More\ BOD_{Bugs} + CO_2 + H_20 + NH_3$

Sewage Treatment

- Sewage, BOD
  - Carbs, Protein, Fats
- Add air and mix well
- Bugs grow
  - And Grow
    - And Grow

Waste excess Bugs to Digester

- With out wasting MLSS goes up, up, up and OUT!
- Waste today what grew today

Biological Chemistry

- Digesters receive no food or BOD
- Endogenous Respiration

$$BOD_{Bugs} + O_2 = \text{Less } BOD_{Bugs} + CO_2 + H_2O + NH_3$$

- Bugs use stored energy
- Some die, and become food for others
- Reduction of Volatile Solids

Digestion Goals

Thicken Waste Activated Sludge: Decanting

Control Odors, Keep it aerobic

Reduce Sludge Volume, Endogenous Resp.

Meet Disposal Requirements

- Land Fill
- Land Application

Aerobic Advantages

- Low Construction Cost
- Easy to Operate
- High Quality Supernatant
- Safer process, no methane

Aerobic vs Anaerobic Supernatant

- Aerobic
  - BOD 500 mg/L
  - TSS 100-300 mg/L
  - TKN 170 mg/L
  - T.Phos 98 mg/L

- Anaerobic

  BOD 1000-10000 mg/L

  TSS 5000- 15000mg/L

  Ammonia 500-1000mg/L

  T. Phos 300-1000mg/L

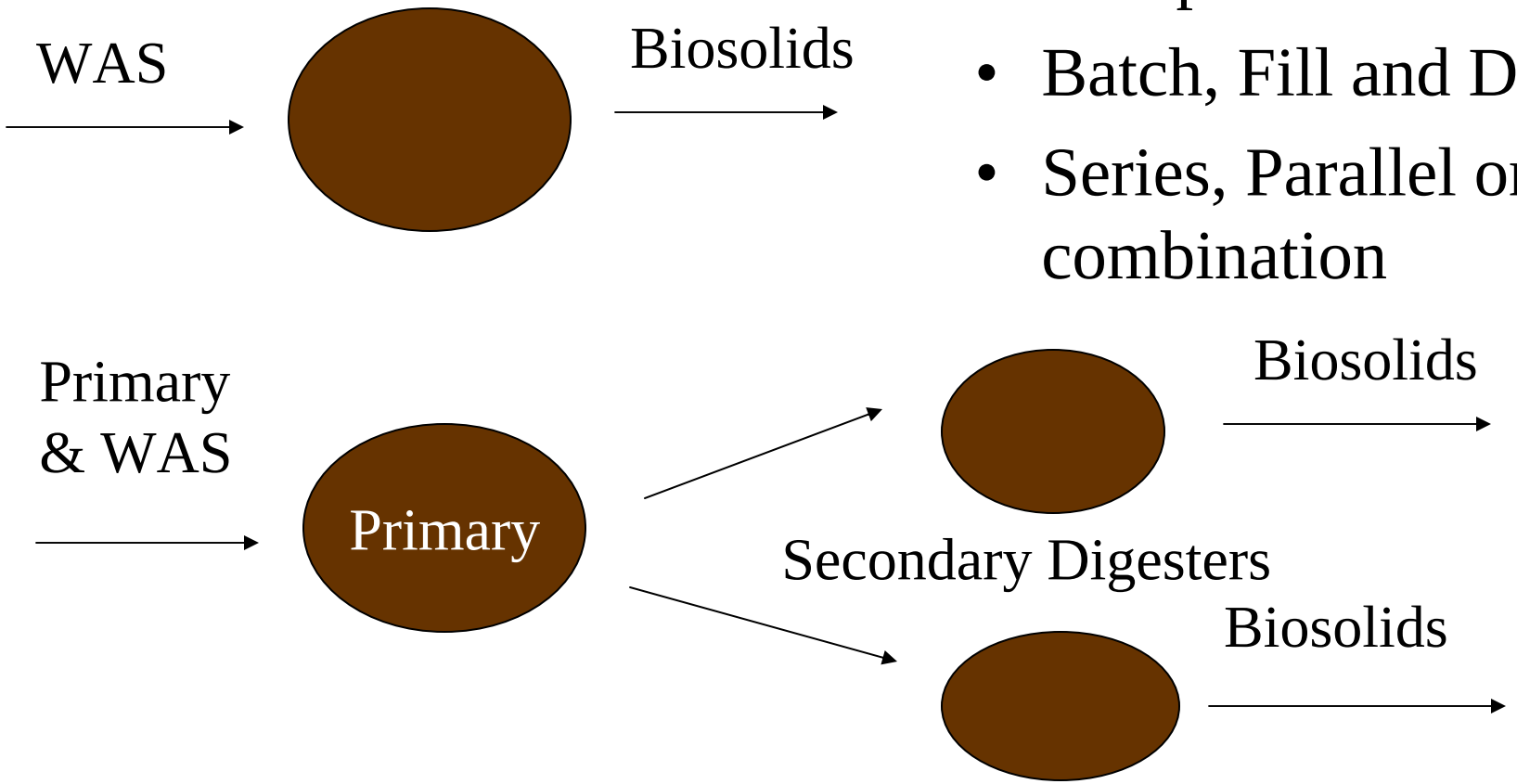
Aerobic Disadvantages

- High Aeration Costs, electricity
- Digested Sludge more difficult to dewater
- Process affected by temperature changes
- More Sludge produced for disposal

Aerobic Digester Design

- Various Sizes
- Various Aeration
  - Diffused air
  - Surface Mechanical
- Various Decant
  - Fixed Valves
  - Moving Arms
  - Telescoping Valves
  - Suspended Pumps

Operating Strategy



- Complete Mixed
- Batch, Fill and Draw
- Series, Parallel or combination

Digester Operations

- Operational Strategy
  - Tools you have
    - Basins
    - Decant or supernatant equipment
    - Aeration
    - Personnel
  - Destination
    - Land Fill
    - Land Application
    - Other Facility

Digester Monitoring

- Daily to Weekly
  - Dissolved Oxygen
  - Settleometer
  - pH, Alkalinity
  - Nitrate
- 503 tests, Prior to use or disposal
  - SOUR
  - Temperature
  - Fecal

Digester Monitoring

Supernatant Monitoring

- Monitor for affects on the water treatment system.
  - Flow
  - BOD
  - Ammonia
  - TSS
  - Nitrate (NO_3)
  - Phosphorus

Land Fill

- Special Waste Permit
  - Division of Solid Waste Management
  - No Free Water, AKA “paint filter test”
  - No Toxic Lecheate, TCLP, Toxic Characteristics Lecheate Proceedure

Land Fill

- Primary Concerns
  - Odor Control, too little O2, too much feed Sludge
    - Oxygen
    - Maintain Oxic environment
    - Sacramento Manual, 1-2 mg/L DO
    - What works for you
      - 0.5 mg/L, can be more cost effective
      - >2.0 mg/L
        - » wastes electricity
        - » can cause low pH
        - » can contribute to foaming

Land Fill

- Dewatering
  - Avoid excessive long aeration times
  - Long times decrease floc and particle size
  - Greater than 20 days, Capillary Suction Time (CST) greatly increases
    - Lower CST means better dewatering.

Land Application

- "503" Requirements
  - Metal accumulation
  - Nitrogen management
  - Pathogen Destruction
    - Class A or B
  - Vector Requirements
    - 38% Red. of V.S.
    - SOUR
    - Bench top test
    - Time and Temp.

Land Application

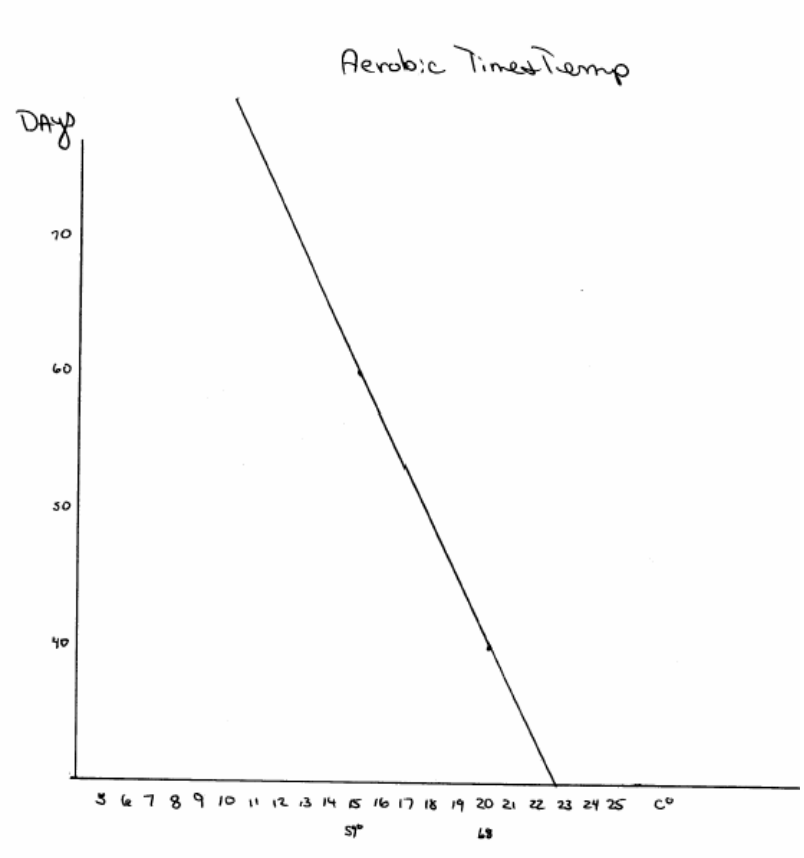
- Concerns
  - Odors
  - Pathogen Reduction
  - Vector Attraction Red.

Land Application

- Class B
  - – Geometric Mean of seven samples is less than 2,000,000 cfu/g
    Requires Total Solids Test for Calculations
- Natural Die off in Digester
  - – Intestinal organisms
  - – Air “Off” cycles appear to assist in reduction.

Land Application

- Class B, PSRP
  - Aerobic Digestion
    - MCRT, 40 days at 20 C
      60 days at 15 C



Land Application

- Vector Attraction Reduction
  - 38% Reduction of VS, Van Kleeck Equation
    - Works best where there is Primary Sludge feed
  - Bench Top Aerobic Digestion
  - SOUR Test, don’t thicken above 2% TS
- All are tests to document Sludge Stability
  - Low BOD (food), Low energy, highly oxidized

Sludge Stabilization

- Requires Time and Air
  - Low Temperature Slows the process
  - High Temps speed the process
- TN Design Criteria
  - 12.5.2.2 “Hydraulic detention time at 20 C should be 15- 25 days depending on type…

Sludge Stabilization

- This may not be enough.
  - Variables
    - Feed Sludge, WAS, Primary, Combination
    - We all have “Winter Temperatures”
    - Design for 20 C guarantees failure in Winter
    - Aeration equipment and location can warm your digester in the winter.

Aerobic Digester Tips

- Low Temperature
  - Slows Pathogen Reduction
  - Slows Volatile Solids Reduction
- High Temperature
  - Speeds Pathogen Reduction
  - Speeds Volatile Solid Reduction

Aerobic Digester Tips

- Low DO
  - does not slow pathogen reduction
  - does not slow volatile solids reduction
- High DO
  - Will cause pH to decrease
  - Will waste electricity

Digester pH Management

- Endogenous Respiration

$$BOD_{Bugs} + O_2 = \text{Less } BOD_{Bugs} + CO_2 + H_2O + NH_3$$

- Ammonia is produced

Digester pH Management

- Where there is Ammonia, There is sure to be nitrification
  - Elements of Nitrification
    - Ammonia Present
    - Old Sludge Age
    - Adequate Oxygen
    - Adequate Temperature
    - Adequate Alkalinity

Digester pH Management

- NH_3+$NH_{3\ Bugs}$ + O_2 + Alk.= More $NH_{3\ Bugs}$ + NO_3

  1 Part 4 Parts 7 Parts

- Nitrification is an expensive process
- If you aerate continuously for long times, alkalinity may drop and pH drop.

Digester pH Management

- If pH drops,
- If nitrates are present

- Turn the aeration "Off" and Denitrify!

Oxygen Usage Hierarchy

Free Dissolved Oxygen	Aerobic or Oxic Treatment
Little or No free Oxygen, but NO_3 present	Anoxic Treatment
Sulfate, SO_4 is the next choice of the Bugs	Anaerobic conditions are beginning. ODORS fm. H_2S

Denitrification

- Normal Bacteriological Respiration

$$BOD + BOD_{Bugs} + O_2 = \text{More } BOD_{Bugs} + CO_2 + H_20 + NH_3$$

1 Part 1.25 Parts

$$BOD + BOD_{Bugs} + \cancel{O_2} = \text{More } BOD_{Bugs} + CO_2 + H_20 + NH_3$$

Denitrification

$$NH_3 + NH_{3\ Bugs} + O_2 + Alk. = More\ NH_{3\ Bugs} + NO_3$$

Nitrogen gas

$$BOD + BOD_{Bugs} + NO_3 = More\ BOD_{Bugs} + CO_2 + H_20 + N_2 + Alk$$

1 Part 0.3 Parts 3.5 Parts

Denitrifying returns alkalinity to the basin and stops pH drop

Agronomic Loading Rates

- Nitrogen Fertilizer value of the Biosolids
- The lower the nitrate the more can be applied per acre.

Agronomic Loading Rates

Parameter	W.Result	RDL	D.Result	RDL	Units	Method	D
Ammonia Nitrogen	BDL	5.0	BDL	480	mg/kg	350.1	06/09
Nitrate-Nitrite	60.	0.10	5700	9.5	mg/kg	9056	06/09
Kjeldahl Nitrogen, TKN	550	100	52000	9500	mg/kg	351.2	06/21
Total Solids	1.05		1.05		%	2540G	06/10
Mercury	0.021	0.020	2.0	1.9	mg/kg	7471	06/16
Arsenic	BDL	0.10	BDL	9.5	mg/kg	6010B	06/10
Cadmium	0.027	0.025	2.6	2.4	mg/kg	6010B	06/10
Chromium	0.17	0.050	16.	4.8	mg/kg	6010B	06/10
Copper	3.8	0.10	360	9.5	mg/kg	6010B	06/10
Lead	0.25	0.025	24.	2.4	mg/kg	6010B	06/10
Molybdenum	0.062	0.010	5.9	0.95	mg/kg	6010B	06/10
Nickel	BDL	0.10	BDL	9.5	mg/kg	6010B	06/10
Selenium	BDL	0.10	BDL	9.5	mg/kg	6010B	06/10
Zinc	11.	0.15	1100	14.	mg/kg	6010B	06/13

Agronomic Loading Rates

Parameter	W.Result	RDL	D.Result	RDL	Units	Method	D
Ammonia Nitrogen	BDL	5.0	BDL	650	mg/kg	350.1	06/09
Nitrate-Nitrite	170	0.20	22000	26.	mg/kg	9056	06/15
Kjeldahl Nitrogen, TKN	360	50.	47000	6500	mg/kg	351.2	06/21
Total Solids	0.770		0.770		%	2540G	06/10
Mercury	0.028	0.020	3.6	2.6	mg/kg	7471	06/16
Arsenic	BDL	0.10	BDL	13.	mg/kg	6010B	06/10
Cadmium	BDL	0.025	BDL	3.2	mg/kg	6010B	06/10
Chromium	0.15	0.050	19.	6.5	mg/kg	6010B	06/10
Copper	2.2	0.10	280	13.	mg/kg	6010B	06/10
Lead	0.22	0.025	29.	3.2	mg/kg	6010B	06/10
Molybdenum	0.043	0.010	5.6	1.3	mg/kg	6010B	06/10
Nickel	BDL	0.10	BDL	13.	mg/kg	6010B	06/10
Selenium	BDL	0.10	BDL	13.	mg/kg	6010B	06/10
Zinc	5.0	0.15	650	19.	mg/kg	6010B	06/13

Agronomic Loading Rates

- Nitrate Levels
  - Digester #1, 5700 mg/L
  - Digester #2, 22,000 mg/L

- Digester #2 Sludge requires 30% more land for application.

Actual Land Application Case

- Biosolids Nitrate
  - 4000-7000 mg/L
  - Not enough land to apply at the present Agronomic Loading Rate
- Initiated “Off- On” aeration
  - 8 hours ON, 16 hours OFF
- Biosolids Nitrate
  - 100-1000 mg/L, 75-98 % reduction
  - Application rates up and no need for more land.

Benefits of Denitrification

- Prevent pH drops by recycling Alkalinity
- Save money by recycling Oxygen
- Apply Biosolids at higher rates
- Improved Dewatering characteristics
- Reduce sludge volume
- Select against filaments

Denitrification reduces the Aerobic Digester Disadvantages

- High Aeration Costs, electricity, Reduced
- Digested Sludge more difficult to dewater, Improved
- Process affected by temperature changes
- More Sludge produced for disposal, Improved

Digester Case Study

- Two Stage
  - Aerated 24/7, odors, odors, odors
  - First Stage, primary and WAS
- Stage Two
  - Low pH, as low as 6.0 s.u. and under,
  - What would you do?

On More Issue
Foaming

- This looks like nocardiaform foam
- If it is a problem…
- Microscopic Exam
- Surface chlorinate
  - 1% Cl_2 liquid spray on the foam when the air is “OFF”
  - More than once per day is better.

More Foam

- Light smelly foam
- Primary Sludge Feed
- Not filaments
- Microscopic Exam
  - Small solids
  - Paper fibers

Aerobic Digesters

- Questions?