Alternative Ways to Achieve Class A Biosolids

Jim (J.E.Smith,Jr.D.Sc.
Chair, USEPA's PEC (Retired)
Cincinnati, Ohio
Email: jesmithjrdsc@aol.com

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What will be discussed?

- Waste Characteristics & Disinfection
- Individual & Collective Treatment
- 40CFR503 - Class A Alternative Treatment Methods
- Examples of Ways to Achieve Class A

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Characteristics of Septage

Parameter	Concentration Minimum	Maximum
Total solids	1,132	130,475
Total volatile solids	353	71,402
Total suspended solids	310	93,378
Volatile suspended solids	95	51,500
Biochemical oxygen demand	440	78,600
Chemical oxygen demand	1,500	703,000
Total Kjeldahl nitrogen	66	1,060
Ammonia nitrogen	3	116
Total phosphorus	20	760
Alkalinity	522	4,190
Grease	208	23,368
pH	1.5	12.6
Total coliform	10^7/100 mL	10^9/100 mL
Fecal coliform	10^9/100 mL	10^9/100 mL

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SOURCES OF WASTEWATER & ASSOCIATED MICROORGANISMS

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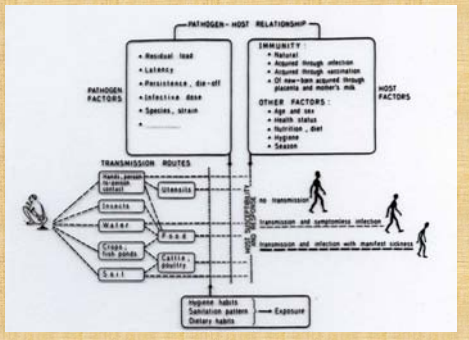
ROUTES OF INFECTION



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CONCERNS / ISSUES

Residences & People

Treatment

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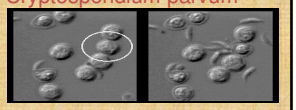
Some culprits…

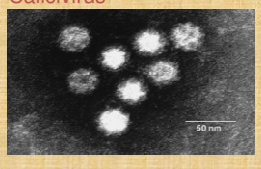
Giardia Lamblia

Cryptosporidium parvum



E.coli

Calicivirus



… What are others?

Pathogens Potentially Present

PATHOGEN CLASS	EXAMPLES	DISEASE
Bacteria	*Shigella sp.*	Bacillary dysentery
	Salmonella sp.	Salmonellosis (gastroenteritis)
	Salmonella typhi	Typhoid fever
	Vibrio cholerae	Cholera
	Enteropathogenic-*Escherichia coli*	A variety of gastroenteric diseases
	Yersinia sp.	Yersiniosos (gastroenteritis)
	Campylobacter jejuni	Campylobacteriosis (gastroenteritis)
Viruses	Hepatitis A	Infectious hepatitis
	Norwalk virus	Acute gastroenteritis
	Rotaviruses	Acute gastroenteritis
	Polioviruses	Poliomyelitis
	Coxsackie viruses	"flu-like" symptoms
	Echoviruses	"flu-like" symptoms

Pathogens Potentially Present Continued

PATHOGEN CLASS	EXAMPLES	DISEASE
Protozoa	*Entamoeba histolytica*	Amebiasis (amoebic dysentery)
	Giardia lamblia	Giardiasis (gastroenteritis)
	Cryptosporidium sp.	Crytosporidiosis (gastroenteritis)
	Balantidium coli	Balantidiasis (gastroenteritis)
Helminths	*Ascaris sp.*	Ascariasis (roundworm infection)
	Taenia sp.	Taeniasis (tapeworm infection)
	Necator americanus	Ancylostomiasis (hookworm infection)
	Trichuris trichuria	Trichuriasis (whipworm infection)

Indicator and Pathogen Organism Concentrations in Domestic Septage

Parameter	Typical Range (counts/100 ml)	Reference
Total Coliform	$10^7 - 10^9$	(10)
Fecal Coliform	$10^6 - 10^8$	(9) (10) (23)
Fecal Streptococci	$10^6 - 10^7$	(9) (10) (23)
Ps. Aeruginosa	$10^1 - 10^3$	(9) (10) (23)
Salmonella Sp.	$1 - 10^2$	(9) (10)
Parasites		
Toxacara, Ascaris Lumbricoides, Trichuris Trichiura, Trichuris Vulpis	Present	(10)

Dose Response Data

Viruses and Parasites

ORGANISM	INFECTIVE DOSE
Poliovirus	1 TCID50, < 1PFU
Cryptosporidium	10 cysts
Giardia lamblia	1 cyst
Helminths	1 egg

All above infective doses are estimates.

Using Multiple Barriers to Protect The Public Health

- Disinfection
- Stabilization (Vector Attraction Control)
- Cropping and Access REstrictions
- Storage

Approach taken by US.

Some Disinfection History

2000 BC

Roman Times







Heavy Metals - Cu

FACTORS ILLUSTRATED
Solar Radiation
Drying / Desiccation
Heat & Time
pH
Filtration
Heavy Metals
Storage / Stabilization

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Standard Treatment Procedure for achieving disinfection and vector attraction control – Using Lime

Add lime to residential septage to raise pH to 12.0

Uses approximately 15, 000 mg/L of lime

Beneficially use

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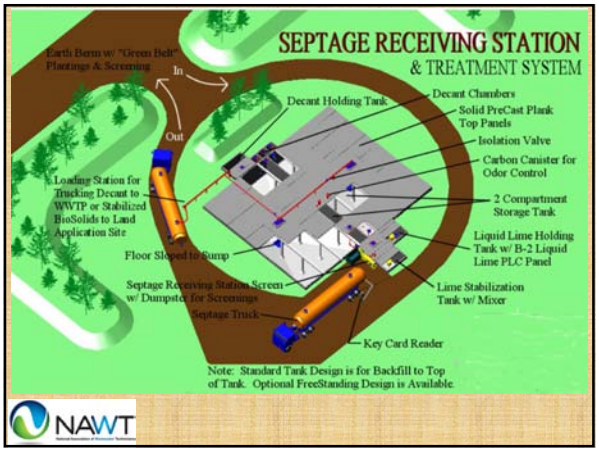

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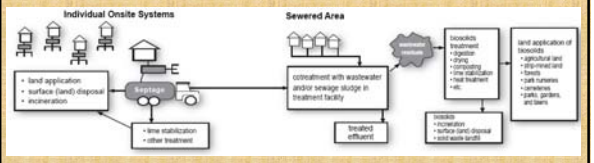
Typical Community Management of Septage and WWTP Residuals



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Class A Sludge Microbiological Criteria

- Must be met by all Alternatives
  - Salmonella = < 3 MPN per 4 g of TS OR
  - Fecal Coliforms = < 1000 MPN per gram of TS
- Must use PFRP Process or Show
  - Enteric Viruses = < 1 PFU per 4 g of TS AND
  - Viable Helminth Ova = < 1 per 4 g of TS

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SIX CLASS A ALTERNATIVES

1. Meet time-temperature requirement – 19%
2. pH> 12 and temp. > 52^{0}C for 12 h. – 12 %
3. Measure V.H.eggs and enterovirus before and after process. If none after process and enough tests, you are O.K. – 4%
4. Test each batch for VHE and enterovirus – 9 %
5. Use a PFRP – 52%
6. Use a PFRP- Equivalent - ~ 2-3%

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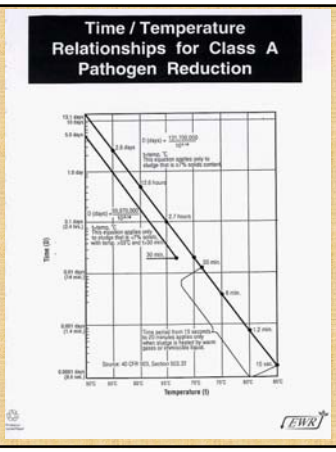
Time and Temperature Guidelines

Total Solids	Temp. (t)	Time (D)	Equation	Notes
≥7%	≥50°C	≥20 min.	$D = \frac{131,700,000}{10^{0.1t}}$	No heating of small particles by warmed gases or immiscible liquid.
≥7%	≥50°C	≥15 sec.	$D = \frac{131,700,000}{10^{0.1t}}$	Small particles heated by warmed gases or immiscible liquid
<7%	>50°C*	≥15 sec. to <30 min.	$D = \frac{131,700,000}{10^{0.1t}}$	
<7%	≥50°C	≥30 min.	$D = \frac{50,070,000}{10^{0.1t}}$	

* in no case would temperatures calculated using the appropriate equation be less than 50°C



THERMAL PROCESSES USING EQUATIONS TO ACHIEVE CLASS A

- THERMOPHILIC ANAEROBIC DIGESTION
- THERMOPHILIC AEROBIC DIGESTION
- PASTEURIZATION
- HEAT DRYING
- OTHER

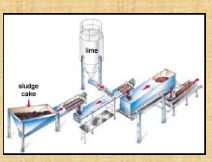
BATCH

Alternative 2: Sewage Sludge Treated in a High pH-High Temperature Process (Alkaline Treatment) [503.32(a)(4)]

This alternative describes conditions of a high temperature-high pH process that has proven effective in reducing pathogens to below detectable levels. The process conditions required by the Part 503 regulation are:
Elevating pH to greater than 12 and maintaining the pH for more than 72 hours.
Maintaining the temperature above 52°C (126°F) throughout the sewage sludge for at least 12 hours during the period that the pH is greater than 12.
Air drying to over 50% solids after the 72-hour period of elevated pH.
The hostile conditions of high pH, high temperature, and reduced moisture for prolonged time periods allow a variance to a less stringent time-temperature regime than for the thermal requirements under Alternative 1. The pH of the sewage sludge is measured at 25°C (77°F) or an appropriate correction is applied.

Class A: Alternative 5 – PFRP Processes

PFRP	
Composting	Be maintained at 55°C or greater for 3 d using in-vessel or static aerated pile composting OR for 15 d, during which compost is turned at least 5 times, in windrows.
Heat Drying	Be dried to 10% moisture or lower AND reach more than 80°C.
Heat Treatment	Be maintained at 180°C for 30 min.
Thermophilic Aerobic Digestion	Be maintained at 55-60°C for 10 d (hydraulic residence time). Volatile solids content must also be reduced at least 38%.
PSRP + Beta Ray Irradiation	Be irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature.
PSRP + Gamma Ray Irradiation	Same as above except irradiation is with gamma rays from isotopes like cobalt or cesium.
PSRP + Pasteurization	Be maintained at 70°C for at least 30 min.

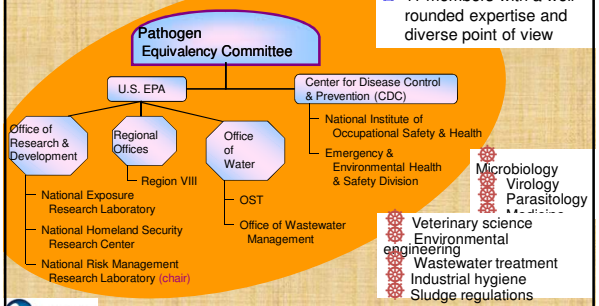


ALT. 6: PFRP EQUIVALENT PROCESSES (4 %)

- BIOSET
- Biochem - BCR
- JVap – US Filter
- Thermophilic Anaerobic Digestion
  - Columbus, Georgia
  - EBMUD
  - Lyonnaise des Eaux – Infilco Degremont
  - Los Angeles
- ATAD
- Magnagro

Pathogen Equivalency Committee

- Created in 1985 to provide technical expertise to permitting authorities on PFRP/PSRP Equivalencies
- 11 members with a well-rounded expertise and diverse point of view

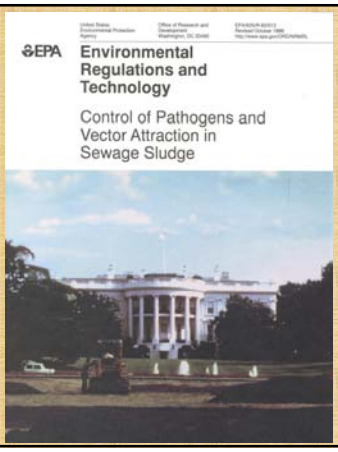


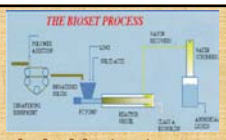
www.epa.gov/nrmrl/pec/index.html

Criteria for Demonstrating Disinfection Equivalency

Mandatory Minimum Requirements

	PSRP Equivalency	PFRP Equivalency
Process Efficiency Parameters:	≥ 2 log reduction of fecal coliform bacteria **and/or** ≥ 2 log reduction of *E. coli* bacteria **and/or** ≥ 2 log reduction of *Enterococcus* spp. bacteria **and/or** ≥ 1 log reduction of *Salmonella* spp. bacteria	**1)** ≥ 3 log reduction of total enteric viruses, **and** **2)** ≥ 2 log reduction of viable helminth (*Ascaris*) ova, **and** **3)** ≥ 5 log reduction of fecal coliform bacteria **and/or** ≥ 5 log reduction of *E. coli* bacteria **and/or** ≥ 5 log reduction of *Enterococcus* spp. bacteria **and/or** ≥ 4 log reduction of *Salmonella* spp. bacteria **and/or** ≥ 4 log reduction of somatic bacteriophages
Process Compliance Parameters (The 40CFR503 Requirements):	< 2,000,000 MPN or CFU/g total solids (TS) of fecal coliform in the treated sludge	Organism densities in the treated sludge of: **1)** ≤ 1 pfu/4 g TS of total enteric viruses, **and** **2)** ≤ 3 viable helminth (Ascaris) ova/4 g TS, **and** **3)** ≤ 1,000 MPN fecal coliform / g TS or = 3 MPN *Salmonella* spp./4 g





- The sludge is held at a temperature of 55°C or greater for a minimum of 25 minutes.
- The solids content of the sludge being treated is in the range of 6% to 35%.
- The ammonia content in the reactor is 1% (10,000 mg/L) on a volume basis.
- The pressure in the reactor is 30 psi.
- The amount of lime added is 0.55 to 0.75 lbs. lime to 1 dry lb. of sludge.
- The amount of sulfamic acid added is 8 to 10 lbs. per dry ton of sludge.
- The pH is greater than 12.

From USEPA-OW-Approval letter of Equivalency

Influence of Temperature, Time, % Ammonia, & Pressure on Ascaris Inactivation

LOCATION	DATE	RUN #	TEMP	TIME IN UNIT	% REDUCTION OF *Ascaris*	% AMMONIA	PRESSURE KPa (psi)
Morgan City	28-May-02	1	42°C	85 min	97.4	0.5	103 (15)
	30-May-02	2	50°C	104 min	87.5	0.05	103 (15)
Kingwood	4-Jun-02	1	45°C	25 min	69.9	0.5	207 (30)
	6-Jun-02	2	46°C	25 min	89.7	0.9	207 (30)
	7-Jun-02	***3***	***55°C***	***25 min***	***100***	***1.0***	***207 (30)***
Sulphur	8-Jul-02	1	50°C	14 min	98.6	0.7*	262 (38)
	9-Jul-02	***2***	***55°C***	***11 min***	***100***	***0.8****	***262 (38)***

* Estimated values based on previous research

Bioset Process Equipment

Mixing the Lime into the Sludge

BioChem

The Neutralizer

Sludge Treatment Process

Report Summary

A Cost Effective Class "A" Biosolids Treatment For Agricultural or Municipal Biosolids

Firm now goes by name of BCR Environmental

Characteristics of Neutralizer Process

Critical process parameters are as follows:

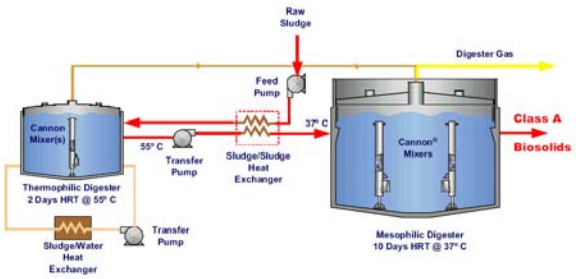
1.	Total solids	≤ 4%
2.	Temperature	≥ 15° C (59° F)
3.	ORP during Stage 1	Oxidant (chlorine dioxide) is added as required to maintain > +100 mV ORP.
4.	Contact time at > +100 mV ORP	1 hour
5.	Nitrite dose	1500 mg/L sodium nitrite ($NaNO_2$)
6.	pH during $NaNO_2$ contact time	≤ 2.3
7.	ORP during Stage 2	> +100 mV
8.	Nitrite contact time at specified pH and ORP	6 hours

Disinfection Capability of Neutralizer Process

Pathogen	Spike Concentration (per 4 g DWS*)	Recovered from Controls (per 4 g DWS)	Recovered after Treatment (per 4 g DWS)	Log Reduction
Ascaris eggs	5×10^4	4.5×10^4	< 1	4
Poliovirus	1.1×10^5	3.5×10^4	< 1	4
	Raw Concentration (MPN/g)	Recovered from Controls (MPN/g)**	Recovered after Treatment (MPN/g)	Log Reduction
Fecal Coliform***	2×10^9	2×10^9	< 1	9

*Dry weight solids **Most probable number per gram dry weight ***Fecal coliform results are from tests conducted on raw sludge.

TWO PHASE ANAEROBIC DIGESTION ID 2PAD SYSTEM



Lyonnaise des Eaux's Two-Phase Thermo-Meso Feed Sequencing Anaerobic Digestion Process

Sewage sludge is treated in the absence of air in an acidogenic thermophilic reactor and a mesophilic methanogenic reactor connected in series. The mean cell residence time shall be at least 2.1 days (± 0.05 d) in the acidogenic thermophilic reactor followed by 10.5 days (± 0.3 d) in the mesophilic methanogenic reactor. Feeding of each digester shall be intermittent and occurring 4 times per day every 6 hours. The mesophilic methanogenic reactor shall be fed in priority from the acidogenic thermophilic reactor. Between two consecutive feedings temperature inside the acidogenic thermophilic reactor should be between 49 C and 55 C with 55 C maintained during at least 2.8 hours. Temperature inside the mesophilic methanogenic reactor shall be constant and at least 37 C.

Run like a batch process – nothing entering or leaving

Performance of 2PAD System Pilot Plant

Variable	Feed Sludge	Acidogenic Digester	Methanogenic Digester
	Mean	Mean	Mean
# Feedings per day	-	4	4
Temperature (°C)	-	55 - 56	37
pH	5.57	6.0	7.2
TS (g/L)	38.5	27.8	21.2
VS (g/L)	27.8	21.3	12.1
VSR	-	23.8	40
VFA total (mgHAc/L)	1,393.3	2,309.8	203
Total ammonia (mg/L)	47.7	552	763.5
Fecal coliform Log (MPN/gTS)	> 6.35	0.9	0.38
Enterovirus Log(PFU/4g TS)	4.04	BD	BD
Viable *ascaris* eggs Log (count/4gTS)	2.61	BD	BD

All pathogen densities are shown in $\log_{10}$. TS: Total Solids, VS: Volatile Solids, TSS: Total Suspended Solids, VSS Volatile Suspended Solids, BD: Below Detection, HAc Acetic acid, VFA: Volatile Fatty Acids, VSR: Volatile Solids Reduction

Some Additional Examples of Ways to Attain Class A that may be useful to Small Facilities

- Quick Lime Processes
  - Bioset – Minster Auglaize Plt, Pop2,794
  - FKC Screw Press
- ATAD
  - Fuchs or Thermal Process Systems
    - Solar Drying
- Composting
  - CleanB-Pretreatment
- Drying
  - CleanB-Pretreatment

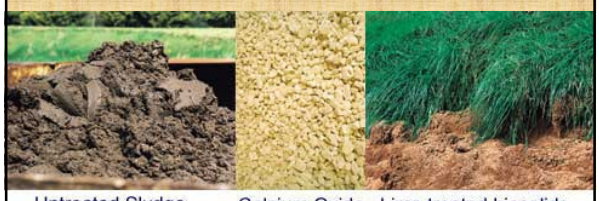
DISINFECTED & STABILIZED SEWAGE SLUDGE /BIOSOLIDS

Lime Use in Treating Sludge (Biosolids)

- PSRP
  - Lime slurry used to raise pH to 12 for 2 or more hours.

- PFRP
  - Quicklime (CaO) added to wet sludge cake to raise temperature to 70°C for 30 or more minutes.
  - Utilizes heat from exothermic reaction to raise temperature and high alkalinity to raise pH.

POST LIME TREATMENT OF SLUDGE



Untreated Sludge | Calcium Oxide | Lime treated biosolids supporting grass growth

Important Considerations with all Lime Processes

- Appear simple, inexpensive, easy option based on rules?
- Determination of Proper Lime Dose
- Proper pH determination
- Effects of Ammonia Gas on pH and Process
- Reactivity of Lime – Carbonated Hydrated Lime!!!
- Time/Temperature/pH
- Odor

Quicklime Reactivity

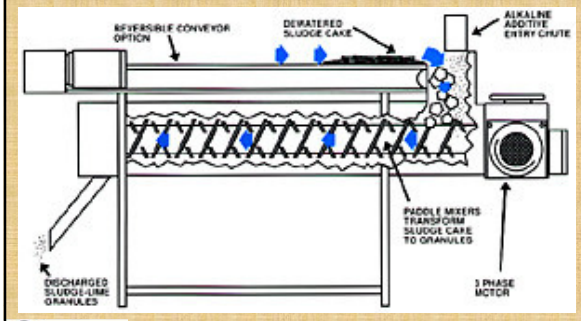
- Some Quicklime is Very (Violently) Reactive With Water
- Small particle Size is Important in Optimizing Exothermic Reaction
- Short Reaction Time Between Quicklime and Cake Biosolid Necessitates Optimum (Small) Particle Size to Maximize Heat Rise

Lime storage is another consideration:

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

Mixing Sludge/Septage & Lime

ROEDIGER POST LIME TREATMENT



Another Mixing Example

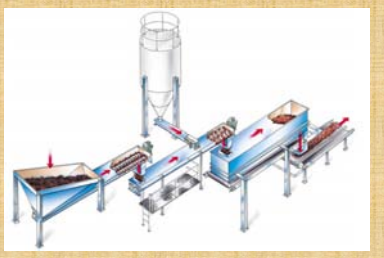
Lime & Sludge Cake Mixing Study At DCWASA Blue Plains WWTP

Better mixing produced lower odors and less vectors

Better mixing also released ammonia quickly, but dissipated quickly

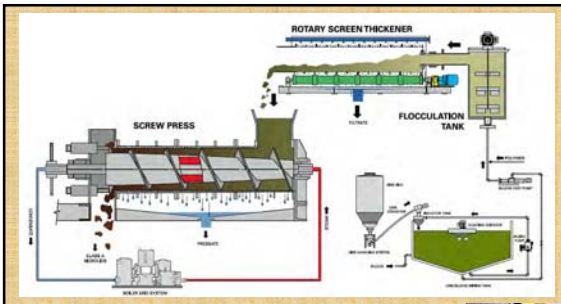
Poorer mixing produced less odors in beginning but odors persisted over longer time frames

RDP Class A Pasteurization Process



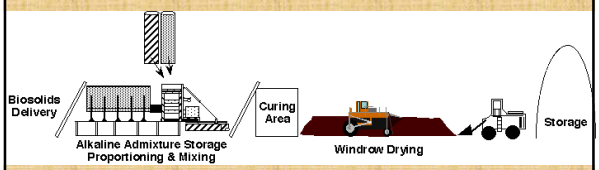
From left to right, you see the sludge receiving hopper feeds the heated screw auger mixer. Lime is added to the mixer from the silo with a transverse auger. Blended material from the mixer is discharged into the pasteurizer where it is held at 70ºC for 30 minutes and then discharged to a conveyor and placed in storage.

Class A Sludge/Septage Cake – Class A Biosolids



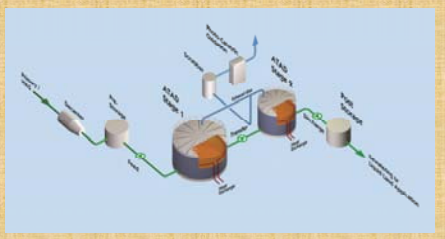
Simultaneous Dewatering & Pasteurization—FKC Class A Process

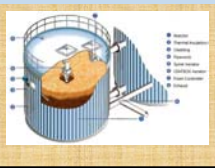
N-VIRO'S PROCESS



N-Viro Process Product

Fuchs ATAD



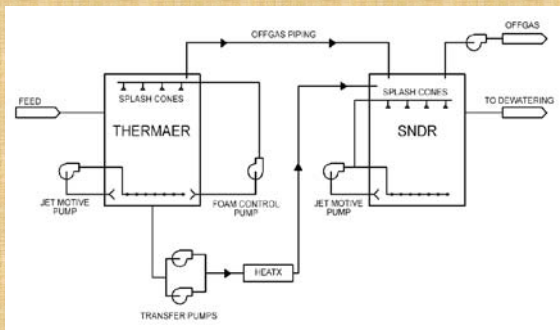


Auto Thermal Thermophilic Aerobic Digestion

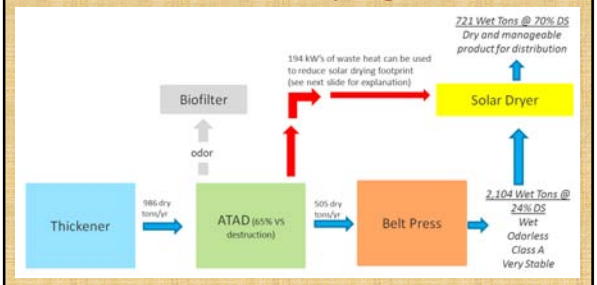
Using Excess Heat - Example

- **Bajo Ebro WWTP in Spain**
  - 1.5 mgd trickling filter plant producing 331 tons dry solids a year
  - Uses NILSA single reactor ATAD system
  - Loading: 32 g/l TS and 22 gr/l VS
  - HRT: 6-8 days
  - VSR: 28%
  - T of the process: 62ºC
- **Characteristics of the building to be heated**
  - Volume: 216 m³ (7628 ft³)
  - Room temperature: in between - 4ºC and +10ºC in fall
  - Time to heat the whole building from 9ºC to 21ºC is one-half hour.

Thermal Process Systems - ATAD



Solar Drying



A solar drying plant without supplemental heat would require two (2) chambers, each 42 ft wide by 216 ft long, or a total area of 18,190 ft². With 150 to 200 kW of waste heat availability you would only need 1 chamber of the same size as the solar only facility.

Solar Drying Bed

CleanB™ Process

•Total solids	≤ 2%
•Temperature	≥ 10° C (50° F)
•ORP	> +100 mV
•Oxidant concentration	50 ppm or more as required to maintain ORP
•Oxidant contact time	10 minutes at > +100 mV

Benefits claimed for CleanB™ Process

- Reduce or eliminate need for digesters in some instances
- Create Class B biosolids in minutes
- Significantly reduce odors of residuals
- Reduce polymer consumption for dewatering
  - +30% reduction in polymer consumption

Aerated Static Pile Composting

Examples of using Thermal Dryers Washington State

Utility	Dryer Type/Brand	Product Amount (dt/year)	Price	Outlet	Annual Revenues
Camas	Belt/Andritz	350	NA	Parks, Golf courses planned	0
Alderwood	Belt/Kruger	300	Free	Compost facility	0
Selah	Indirect/Fenton	200	Free	Land application	0
Shelton	Belt/Andritz	Est. 500-750	Free	Give away to farmers	0

Example of Belt Dryer – Veolia Krueger BioCon





Example of Rotary Drum Dryer

Questions?