Energy Balance and Nutrient Removal Impacts of Food Waste Disposers on Wastewater Treatment

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Overview

- Food Waste Management Strategies
- Properties of Food Waste Relative to Wastewater
- Technical Evaluation of Grinding
- Transformations of Food Waste in Sewers
- Energy Recovery from Food Waste
- Utilization of Food Waste in Wastewater Treatment
- Summary of Findings

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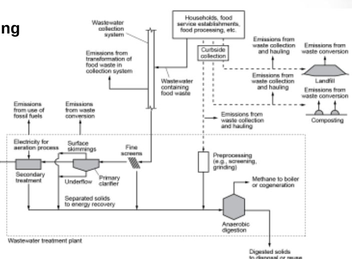
Food Waste Management Strategies

- **Onsite Composting**
- **Commingling with Solid Waste**
- **Centralized Composting**
- **Centralized Anaerobic Digestion**
- **Blending with Wastewater**



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Properties of Food Waste Relative to Wastewater

- **Generation**
  - 0.1 kg/capita•day (wet)
  - 30 g/capita•day (dry)
- **Characteristics**
  - General Formula
    $C_{21.53}H_{34.21}O_{12.66}NS_{0.07}$
- **Energy Content**
  - 14.06 MJ/kg organic fraction COD
  - 3.6 MJ/kWh
  - 3900 kWh/MT COD
  - 1.44 g COD/g Food Waste
  - 5600 kWh/MT Dry Food Waste

	Value (dry basis)	
Constituent	g/kg food waste[a]	g/capita•day[b]
COD	1155	34.6
BOD	533	16.0
Sol. BOD	312	9.4
TSS	409	12.3
O&G	323	9.7
TKN	21.3	0.64
TP	2.8	0.08
S	3.5	0.11

[a]Dry basis, food waste Total Solids 17%.
[b]Based on per capita food waste generation of 30 g/capita•day (dry)

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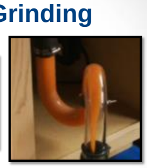
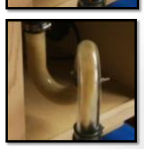
Technical Evaluation of Grinding

- **Particle Size**
  - Standards of the American Society of Sanitary Engineering (ASSE) *100% Less Than 13 mm*
  - 90% Less Than 3 mm
  - ~40% Less Than 100μm
- **Energy Consumption**
  - 0.008 kWh/capita•day
- **Water Use**
  - Insignificant at Less Than 1% of Residential Usage
  - 5 L/household•day





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Transformations of Food Waste

- **Aerobic Conditions**
  - Portion of soluble food matter may be converted to CO_2
  - Slight Decrease in Oxygen Demand
  - Slight Increase in Particulate Matter from Biomass Growth
- **Anaerobic Conditions**
  - Products of Hydrolysis & Soluble Food Matter Subject to Acidogenic and Acetogenic Reactions Resulting in Short Chain Fatty Acids, Useable for Methanogenesis, Sulfate Reduction, or as Carbon Source for BNR

Sewer conditions are highly variable and site specific, no transformations assumed for modeling.

- **Within the Treatment Plant**
  - Partial Removal During Primary Clarification
  - Soluble & Colloidal Matter to Secondary Aeration

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Energy Recovery from Food Waste

- **Strategies for Food Waste Recovery from Wastewater**
  - Primary Clarification
  - Fine Screens
  - Microscreens
  - Advanced Primary Treatment
  - Charged Bubble Flotation
- **Theoretical Biogas Generation**
  - 203 m^3/MT (wet)
  - 677 m^3/MT (dry)

Observed Values from Digestion[a]

Parameter	Unit	Range	Typical
Total Solids	%	25-28	27
Methane Content	%	64-75	70
Volatile Solids/Total Solids	%	86-95	90
Volatile Solids Destruction	%	74-82	80
Biogas Yield	m^3/MT (wet)	150-160	157
	m^3/MT (dry)	500-650	600
Methane Yield	m^3/MT (wet)	100-120	110
	m^3/MT (dry)	375-450	420
Energy Production[b]	kWhe/MT (wet)	270-300	280
	kWhe/MT (dry)	900-1200	1100

[a] Adapted from Kennedy Jenks (2009), EBMUD (2008), Zhang et al. (2005), Cho et al. (1995).
[b] Based on assumed generator electricity output of 1.8 to 2 kWhe/m3, potential heat output of 4 to 5 kWh/m^3 of biogas used for digester not included.

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Utilization of Food Waste in Wastewater Treatment

- **BioWin Used for Modeling Three Types of Plants**
- **Anaerobic Digestion**
- **Combined Heat & Power**

Model #1	Model #2	Model #3
Activated Sludge with Nitrification	Activated Sludge with Nitrified Mixed Liquor Recycle	Biologic Nutrient Removal (BNR) with Primary Fermentation
Conventional Activated Sludge	Modified Ludzack-Ettinger	5-Stage Bardenpho
AS	MLE	BNR

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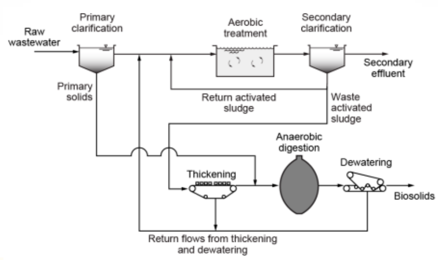
Conventional Activated Sludge (AS)



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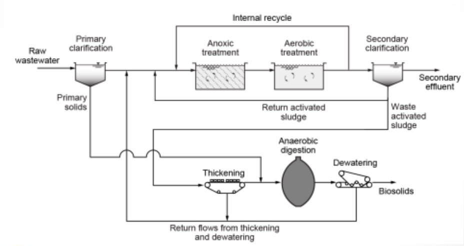
Modified Ludzack-Ettinger Process (MLE)



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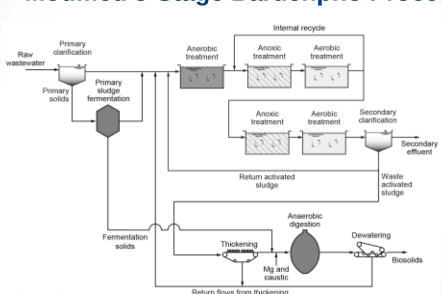
Modified 5-Stage Bardenpho Process



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Influent Modeling Data

		Food Waste Disposer Utilization (%)			
Parameter	Unit	0	10	50	100
Flowrate	MGD	10	10	10	10
COD	mg/L	438	451	500	562
CBOD	mg/L	230	236	267	304
TKN	mg/L	43.0	43.2	44.1	45.1
TP	mg/L	8.30	8.33	8.44	8.59
Nitrate	mg N/L	0	0	0	0
pH		7.3	7.3	7.3	7.3
Alkalinity	mmol/L	6	6	6	6
TSS	mg/L	189	194	211	243
Inorganic SS	mg/L	31.0	31.4	32.8	34.6
Calcium	mg/L	80	80	80	80
Magnesium	mg/L	15	15	15	15
Dissolved Oxygen	mg/L	0	0	0	0

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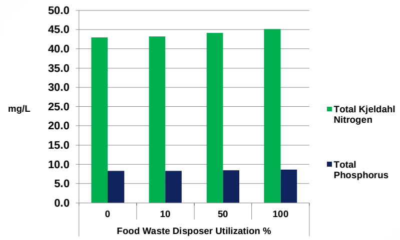
Disposer Impacts to Wastewater Influent



*Based on a 10 MGD WWTP and a per capita water usage of 75 gal/day

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5% Increase in Nitrogen
3% Increase in Phosphorus

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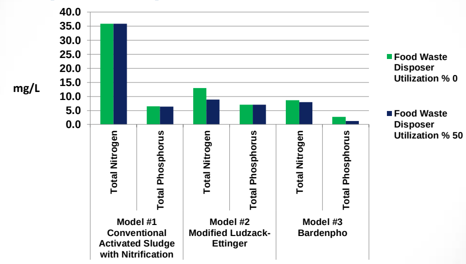
Disposer Impacts on Effluent Nutrients



*Based on a 10 MGD WWTP and a per capita water usage of 75 gal/day

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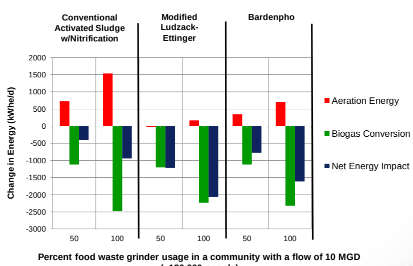
Net Energy Gain for Wastewater Treatment



Percent food waste grinder usage in a community with a flow of 10 MGD (~130,000 people)

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Summary of Findings

1) Greatest Energy Benefit Results from Carbon Used for Nitrate Removal
2) Food Waste Disposer Usage Improves Nitrogen and Phosphorus Removal in MLE Processes and Phosphorus Removal in Bardenpho Processes
3) Food Waste Provides a Carbon Source for Biological Nutrient Removal ***and*** Substrate for Biogas Production
4) Processing of Food Waste Via Disposers Can Result in Energy Recovery, Enhanced Nutrient Removal, and Recovery of Organic Matter for Agricultural Systems
5) Site Specific Modeling Necessary to Project Impact of Disposers on a Particular Wastewater Treatment Systems and Optimal Utilization of Influent Food Waste

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