

The Development of an Acid/Base Reaction derived from the Fertilizer Industry coupled with Sewage Sludge Producing a Commercial Organically Enhanced Fertilizer

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Municipal sludge fertilizers in the 1930's

Municipal sludge was heat dried, forming fertilizer in Houston and Milwaukee (Milorganite) with the following concerns:

- Potential explosions and fires
- Unstable when moisture adsorbed in the dried sludge
- Presence of potential toxins before the advent of the pretreatment guidelines

Genesis of Unity Technology

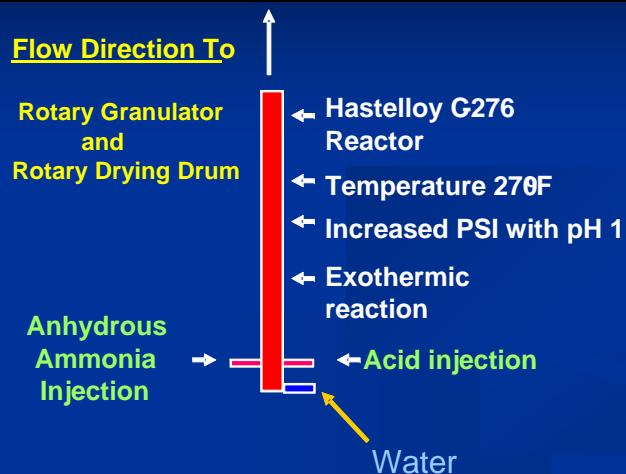
- World War II
- The Anhydrous Ammonia Problem
- TVA Solution

Evolution from the standard technology

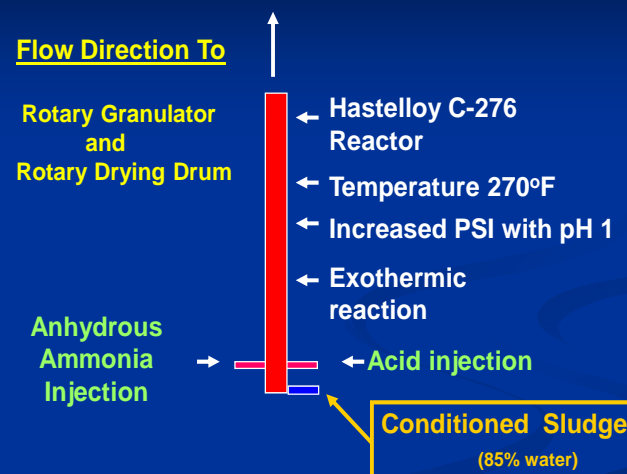
Standard Fertilizer Technology

Unity Technology

Typical Pipe Cross Reactor

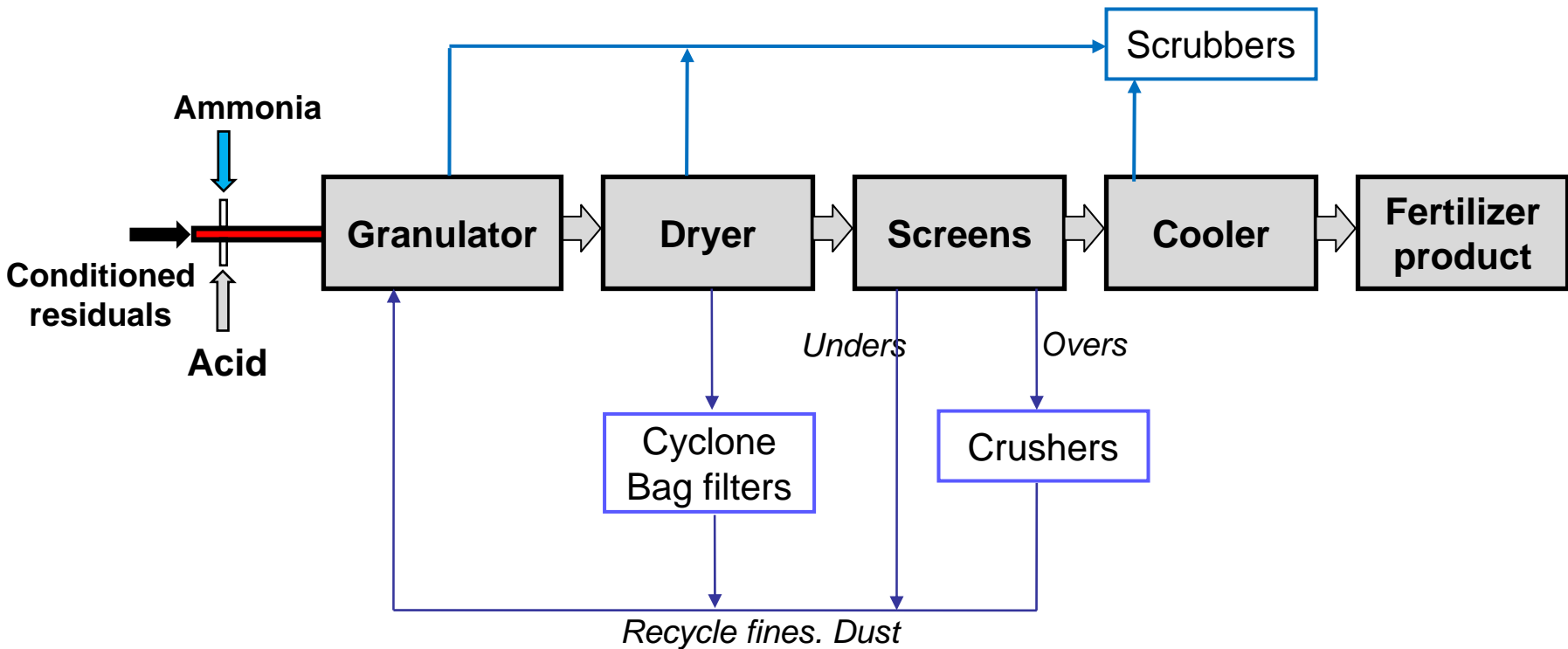


Unity "Pipe Cross Reactor"

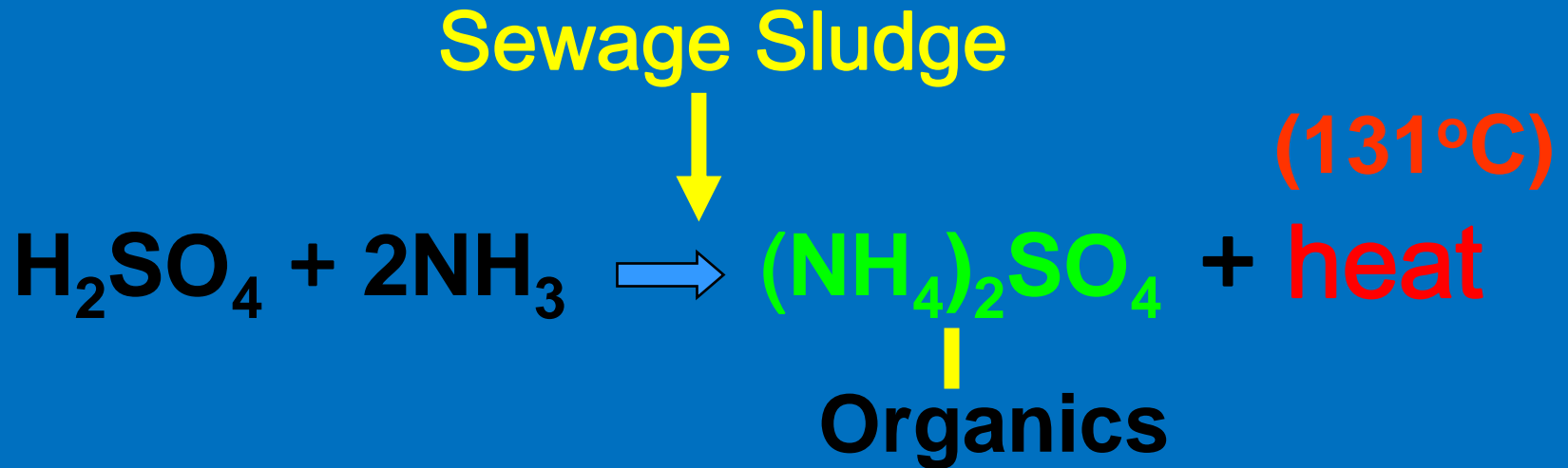


- Pre-treated sludge replaces water used in traditional fertilizer manufacturing
- The Unity process sterilizes and converts sewage sludge to amino acids and other organic materials in the Fertilizer

Unity process flow diagram



Unity Process Reaction



(131 °C = Sterilization Temperature)

Process details

1. Pumping Conditioned Sludge to a Pipe-Cross Reactor used for mixing a base (anhydrous ammonia), acid (sulfuric acid) to form a slurry.
2. Flashing off the water in the slurry as steam.
3. Spraying of the slurry into the cascading bed of recycled particles in a rotating drum granulator to form accreted (onion-like) granules.
4. Drying, screening and cooling of the granules to achieve the finished fertilizer product.

Sewage sludge conditioning by low pH and temperature

- Preconditions all types of residuals: raw, aerobic/anaerobic digested
- Controls product stability and eliminates odors
- Eliminates product dust, explosion potential and combustibility

Critical Conditions (High Temperature and low pH)

- Microbial disinfection to sterilization
- Forms organically enhanced nitrogen sulfur fertilizer
- Hydrolyzes and oxidizes proteins to amino acids

Pilot Plant Studies

- Plants ran 4 days per week
- 100 to 200 kg/h
- This data is being utilized to design 500 to 1500 tons/day fertilizer processing facilities

Unity Technology validated in full scale



Physical Properties of Unity and Urea Fertilizers

	Unity Fertilizer	Urea Fertilizer	Comments
Critical Relative Humidity, %	80 -85	70 - 75	
Moisture Penetration, cm	0.5 -1.0	15	Enhances stability due to resisting moisture adsorption
Moisture Absorption, mg/cm²	41 – 144	350	Same as above
Moisture Content, %	2.3 (4.9 -0.4)	--	
Solids Content, %	97.7 (95.1 – 99.6)	--	Within the stability criteria of > 90 %
Oxidation Reduction Potential, mV	+ 350		Above the – 300 mV criteria

Physical Propertiesctd

	Unity Fertilizer	Urea Fertilizer	Comments
Abrasion Resistance, % Degradation	0.49 – 0.99	0.2 – 3.0	
Granule Crushing Strength, kg/granule	2.0 – 2.6	1.5 – 3.5	Good for fertilizer application
Granule Integrity	Excellent	Fair to Good	Good for fertilizer application
Bulk Density, loose, kg/granule	825 - 875	720 -820	
Angle of Repose, degrees	35	34 - 37	
Combustion Potential	0	N.A.	
Chemical compatibility (TSP, KCL)	Compatible	Limited	

Unity Product Stability

- The process is monitored through pH, temperature and oxidation-reduction potential (ORP)
- The final solids content is around 98 %
- The final solids ORP is + 350 mv or well above the – 300 mv required to produce odorous compounds
- Fertilizer has a negligible moisture adsorption

Stability Control

- Combustion and self-heating eliminated
- Putrefication and regrowth inhibited due to a sterile product
- Vector attraction is controlled due to high solids content and ORP
- Odor release eliminated as a result of the solids content and ORP

Chemical Properties of Unity Fertilizer

	# of Samples	Average %	Standard Deviation	Range, %
Total Nitrogen	12	17.6	0.3	18.0 -17.0
Total Phosphorous	12	1.1	0.08	1.3 – 1.02
Total Sulphur	12	19.4	0.4	20.3 – 18.7
Amino Acid Content	12	3.0	0.3	3.25 – 2.3
Total Iron Content	11	2.3	0.2	2.7 – 2.1
Total Carbon Content	11	4.7	0.4	4.98 – 4.21
Total Organic Matter	11	7.6	0.6	9.0 – 6.9

Control of Metals

- Dilution reduces the concentration 6 to 7 times.
 - Can adjust product/fertilizer metal content to meet the most severe restrictions (e.g. ES, DK)
- Product has been shown not to release heavy metals even at a pH = 1.

Comparison of Heavy Metal Levels mg/kg DS

Metal	Unity	AAPFCO *	EPA **	SST ***
Cd	1.6	10	39	3.9
Cu	46	-	1500	310
Pb	7.4	61	300	100
Hg	0.14	1	17	2.3

* Fertilizer metal criteria

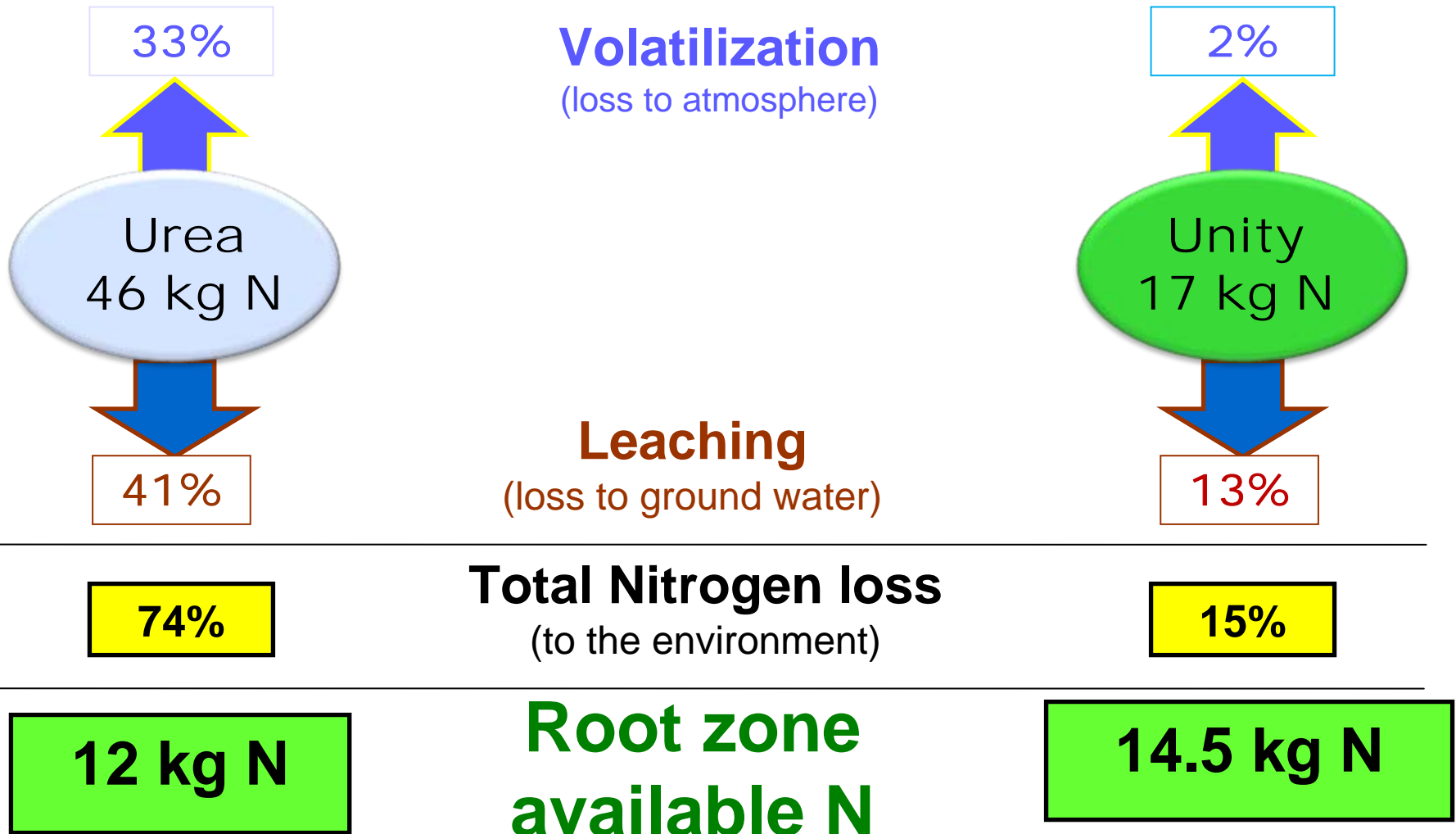
** US EPA exceptional quality metals criteria

*** Soil screen test for non-contaminated residential soils

Heavy metal contents mg/kg

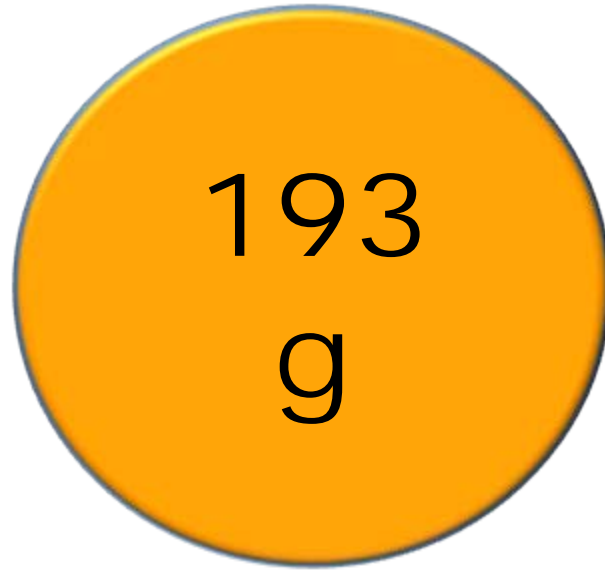
Metal	Unity Fertilizer	AAPFCO Food Criteria	EPA 503	Soil screening test
As	3.3	13	41	12*
Cd	1.6	10	39	3.9*
Cr	8.8	-	1200	23*
Cu	46.5	-	1500	310
Pb	7.4	61*	300	100
Hg	0.14	1*	17	2.3
Ni	10	250	420	16*
Se	1.6	26	36	20
Zn	107	420	2800	230*

Fate of nitrogen from 100 kg of applied Urea versus Unity fertilizer

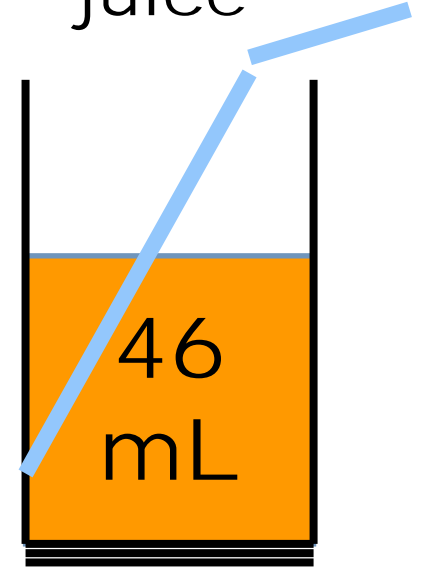


orange

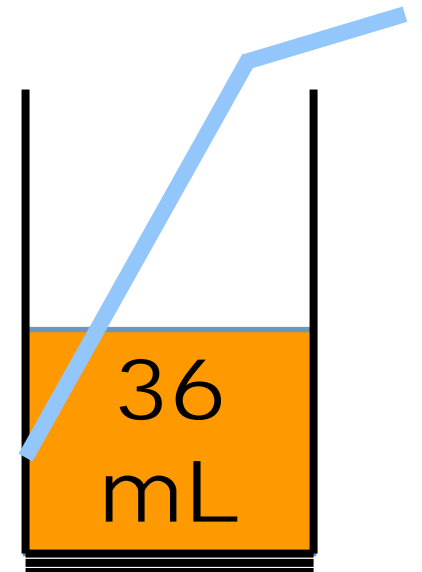
Unity
17 N



juice



Urea
46 N



Summary of Yields for 1 Orange

- Unity Fertilizer increases the weight of the orange by over **17 %** over Urea.
- Unity Fertilizer increases the volume of orange juice by over **30 %** over Urea.

UNITY - Treated Rice

- Well-developed roots
- Earthworm balls in roots
- Superior growth by 5" to urea

Net Profit Increase:
\$43/acre
~ \$344,000 on 8000 acres

July



September



Unity Bermudagrass Study

200 #/acre of Fertilizer Applied	Yield Dry Matter	Percent Increase in Dry Matter	Crude Protein in Percent	Percent Increase in Crude Protein
Unity (17-1-0-19)	3,086	> 6.6 %	19.6	> 4.4 %
Triple (17-17-17)	2,903	---	15.2	---

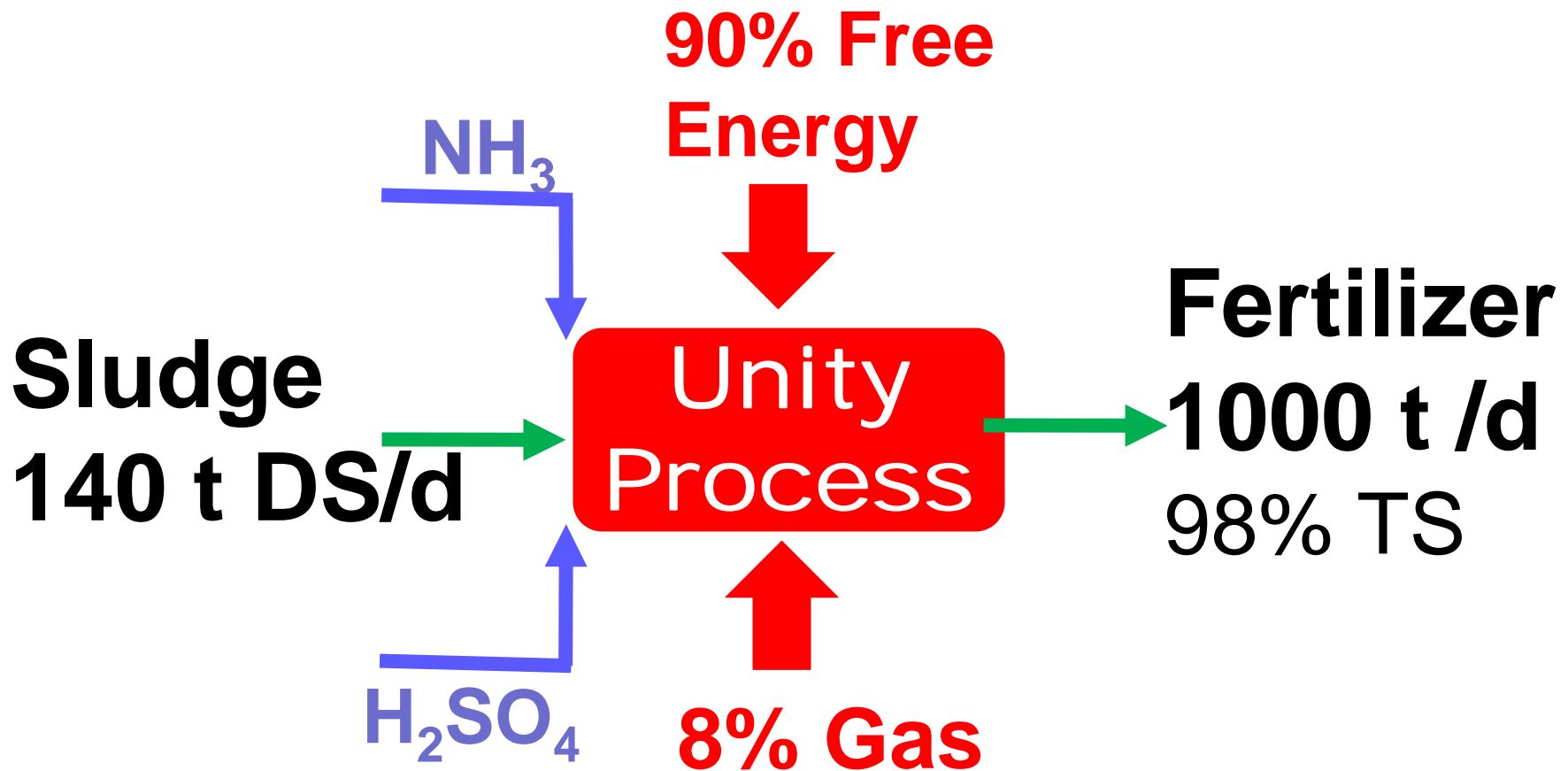
Unity Fertilizer- Turf Grass Study

Treatment	Grams of Grass per 0.1square meter	Percent Increase Yield due to Application of Unity
Urea	296	61 %
Ammonium Sulfate	316	51 %
Sulfur-Coated Urea	269	77 %
Methylene Urea	234	103 %
Unity	476	-----
Untreated	143	233 %

Unity Fertilizer- Turf Grass Study
(Relative to Chlorophyll Content in Turf Grass)

Treatment	Chlorophyll Content	Percent Increase Yield due to Application of Unity
Urea	2.5	56 %
Ammonium Sulfate	3.0	30 %
Sulfur-coated Urea	3.0	30 %
Methylene Urea	2.8	39 %
Unity	3.9	-----
Untreated	1.1	255 %

**140 t DS/d sludge →
1000 t/d fertilizer**



Summary

- Typical application **200 kg/ha*year**
- **140 t DS/d** sludge → produces **1000 t/d** of enhanced (5 %) organic nitrogen sulfur fertilizer
- Fertilizer product sterilize due to temperature, time, pressure and pH
- These stressors have the potential to react with endocrine disrupting chemicals and pharmaceuticals

Summary

- Enhanced food quality and yield from the field when compared with urea fertilizer
- Much lower carbon footprint than urea fertilizer due to minimal losses of nitrogen (source of N_2O)

