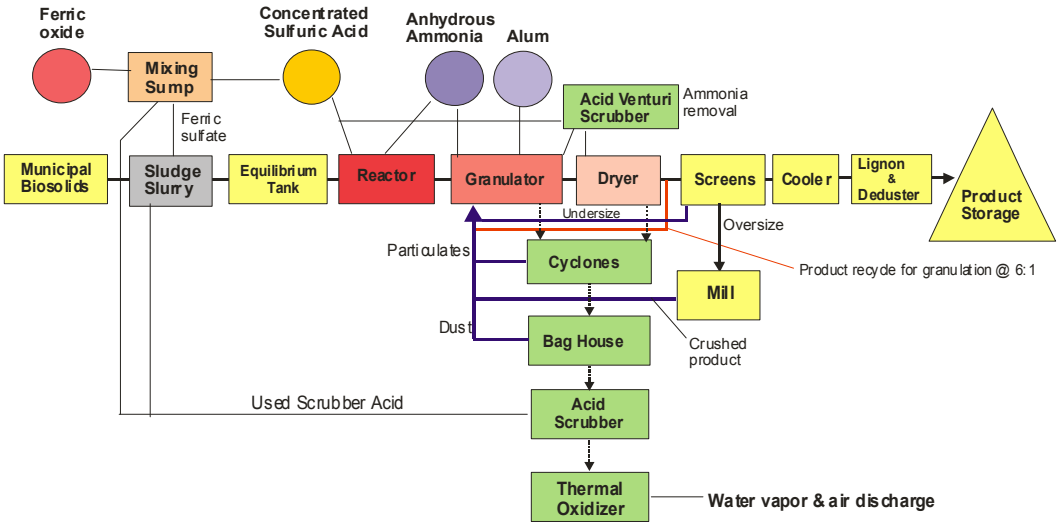
Municipal Wastewater To Real Fertilizer: The Unity Fertilizer Solution

Jeffrey C. Burnham, Ph.D.
Gary L. Dahms
Unified Environmental Services Group LLC

The Unity Process, invented in the late 1990's, has been operating on a full scale basis since 1999 in a converted ammonium sulfate fertilizer plant located in Helena, AR. This presentation follows one made to this Roundtable several years ago and emphasizes the effects of changes made to the Unity process as well as the crop productivity findings from the use of this different fertilizer.

Municipalities are changing the ways in which they have been dealing with the disposition of their sludge or as it is now known, biosolids. The strategy of spraying liquid sludge on the ground as an organic fertilizer is being gradually eliminated due to odors, pathogens and general ground water contamination. Municipalities are now looking for beneficial reuse strategies where their biosolids can be made into useful products. The two strategies that do not increase the volume of this material are heat drying the biosolids into pellets and the Unity process. Heat dried pellets were popular in the 1990's when their value was high enough to support significant transportation to end users. However with an increase in the amount of these pellets their value has diminished and the most recent drying plant in the Midwest simply mixes the pellets with soil and buries them.

The Unity process initially goes against the paradigm of treating municipal biosolids, i.e., always trying to dry and stabilize the sludge. The Unity process instead, takes this dewatered sludge cake that is between 20 and 30% solids, and liquefies this material into a pumpable slurry. This slurry is then used to cool the reaction between concentrated acid and anhydrous ammonia in the Pipe Cross Reactor. The process can be diagramed as follows:



The critical chemical reactions in creating the Unity product take place in the Pipe-cross reactor. Only after the reaction melt exits the Reactor does the Unity process dry the material by relying on a combination of chemical thermal energy and combustion energy to remove water from the biosolids. This process results in a hard fertilizer granule that contains less than 2% moisture.

The reactor is allowed to operate at about 270F with a pH of 1 with significant atmospheric pressure. At these conditions a number of important things happen that affect the quality and properties of the Unity fertilizer product: a) inorganic salts are formed from the reaction of acid with anhydrous ammonia; b) microbial sterility is achieved which causes the Unity product to meet the time/temperature requirements of the USEPA 40CFR Part 503 rule for a Class A biosolids process and product; c) a hydrolysis of many of the organic macromolecules, such as proteins, that are present in the biosolids occurs; and d) these organics bind with the inorganic salt created in the reactor to form complexes that will resist volatilization and that will slow passage of the complex through the soil column.

As can be seen from the diagram above, the Unity process utilizes much of the machinery employed in traditional fertilizer granulation plants, as in the manufacture of ammonium sulfate, MAP or DAP. This is one of the strengths of this technology. The granulation process is robust and has been proven and utilized for over 50 years. The unique part of the Unity process is the ingenuity in figuring out how to effectively replace reactor cooling water with dewatered biosolids.

It is also significant that the Unity product meets important market requirements for beneficial use in agriculture. The inorganic plant nutrient level in the Unity product is 17-1-0-19 (% by weight of N:P:K:S) with approximately 15% organic content, 2% Fe and significant amounts of other micronutrients such as Mn and Zn. The guaranteed 17% nitrogen by weight in this product is the highest of any product containing municipal biosolids and, of course, contributes significantly to the market value of the finished fertilizer. The absence of significant water in the product requires that it be handled as a typical commodity fertilizer product requiring dry storage until use.

Unity NS+, an organically-enhanced ammonium sulfate product, with a finished pH of approximately pH 6 and a granule hardness of over 6 pounds, has been applied (typically 150 to 400#/acre) to carrots, citrus, corn, cotton, rice, along with bermudagrass, turf and wheat with positive production results when compared to traditional fertilizer practices using nitrogen fertilizers such as ammonium sulfate, ammonium nitrate and urea. The following examples document some of the crop results.

Urea is the most popular N fertilizer source used in delayed-flood rice production. Because of urea's potential for loss via ammonia volatilization it should not be applied more than 5 days prior to flooding. The problem is many rice farmers cannot flood their rice fields in 5 days or less and they can lose 20 to 25 % of their urea fertilizer applied via ammonia volatilization if they take 7 to 10 days to flood their rice field. Unity NS+ was applied up to 10 days preflood in a study at the Stuttgart, AR Agricultural Experiment Station with excellent productivity. No loss in terms of bushels of rice produced occurred, i.e., about 180 bushels/acre, when Unity was used at 120 and 150 pounds of N

per acre at 1 day, 4 days, 7 or 10 days prior to flooding. Only when Unity was used at 60 and 90 pounds of N/acre did the productivity of the Unity-treated crop drop off significantly when compared to urea when it was used at 1 day prior to flooding. It appears that decreased volatilization is important in determining this result.

When used with dry land wheat the productivity with Unity as been good. A central Minnesota planting yielded the following average results.

Treatment	Heads	Group Plant Length
Unity @ 250#/acre	317 ave.	29" ave.
Unity @ 250#/acre in (15-6-0-15)	186 ave.	29" ave.
Check (no fertilizer)	96 ave.	25" ave.

When Unity was used with winter wheat (FFR547) in Tennessee in combination with urea (68+32 # of N respectively) the productivity equaled that of ammonium nitrate (100#N) and urea alone (100#N), i.e., 49.4, 51.6 aand 48.5 bushels/acre.

Unity NS+ has been used in citrus now in both California and Texas with positive results. When orange trees treated with Unity were compared to urea-treated trees, both at 1.5# fertilizer per tree (Unity N = 0.26#/tree and urea N = 0.69N/tree) the following results were recorded in Southern California.

Day	Date	Parameter	Unity @ 1.5#/tree (0.26 # N/tree)	Urea @ 1.5#/tree (0.69 # N/tree)
0	5/14/2002	SPAD	22.7.	22.7
		Fruit Wt	na	na
		Juice ml/fruit	na	na
45	6/29/2002	SPAD	46.1	40.4
		Fruit Wt	na	Na
		Juice ml/fruit	na	Na
94	8/18/2002	SPAD	62.6	61.4
		Fruit Wt	207	182
		Juice ml/fruit	34.8	27.3
126	9/14/2002	SPAD	53.0	51.4
		Fruit Wt	192.9	164.8
		Juice ml/fruit	46.4	36.5
		BRIX (sugar)	9.2	8.8
160	11/19	SPAD	79.5	67.4
		Fruit Wt	204.7	166.2
		Juice ml/fruit	68.8	39.1
		BRIX (sugar)	10.6	10.1

The results indicate that the chlorophyll level (SPAD readings) were higher in the Unity-treated oranges and so was the fruit weight and amount of juice per orange. The enhanced value of the Unity-treated fruit is also evident with their higher sugar readings (BRIX).

Unity NS+ has been very useful as a fertilizer for turf and forage. As was found with citrus, an increase in chlorophyll content (and greenness) is consistent in its use with the grasses. This has been measured with turf for golf courses as well as forage grasses. For example, this year we participated in a study on bermudagrass in Arkansas. The results with Unity NS were very positive, not because of the amount of grass produced—it was the same as produced from a triple 17 fertilizer—but because the quality of the grass produce was superior to that obtained with the 17-17-17. In the bermudagrass treated with Unity NS+ the Crude Protein was up over 4% and the Total Digestible Nutrient was up by 14.9%. Both of these parameters are important in setting the value of this forage crop.

In summary, this Unity fertilizer is a unique plant food product in that it has inorganic nutrient ammonium sulfate coupled with hydrolyzed organic molecules linked with micronutrients. The properties that result have positively impacted multiple crop productivity consistently over three seasons of use.