"WHERE'S THE BULK?" – WITH UPDATED OPERATIONAL INFORMATION BULKLESS BIOSOLIDS COMPOSTING AT THE SAN ANGELO WATER UTILITIES' KICKAPOO COMPOSTING FACILITY

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ABSTRACT

Last year we asked the question, "Can digested municipal sewage sludge be composted without bulking material?". The answer continues to be YES and we would like to share with you how we accomplished it. During the last year changes were made to operational procedures that have increased the efficiency of the process. We would like to share the new operational procedures that make bulkless composting an even more viable option for beneficial use of biosolids.

Traditionally, composting of biosolids is accomplished by combining bulking material with the incoming feedstock. These bulking materials usually consist of some type of readily available wood or fibrous material that is processed to form chips. In arid regions these types of materials are not generally available in large quantities or in surplus. San Angelo is located in the semi-arid region of West Texas. A significant amount of brush and lumber is already being diverted from the City's landfill and utilized by the contract operator in a composting operation. The lack of a source for bulking material did not dissuade the city from its goal of diverting biosolids from disposal in the landfill and producing a useful product. As a part of a solids management improvement project at the Water Reclamation Facility, the City sought to "complete the circle" in their solids management.

Communities in New Mexico have been successfully composting without bulking materials for many years. These communities readily shared information about their operations that convinced city staff of the feasibility and the advantages of bulkless composting. Subsequently, the City of San Angelo has been successfully composting anaerobically digested biosolids without the use of bulking materials since December 2003. A cost benefit analyses for the city's operation demonstrates that bulkless composting can be conducted for less cost than a traditional composting operation and for less cost than disposing of the material in a landfill.

The City of San Angelo's Kickapoo Composting Facility is a 12 acre facility consisting of approximately 6.5 acres of concrete working surface, a stormwater detention pond and

an administration building. Dedicated equipment includes a front-end loader, self-propelled windrow turner and a water truck. The facility is adequately sized to compost all the material that is produced from the treatment plant which averages 250 cubic yards per week.

This discussion is intended to outline the benefits of composting without bulking materials; to discuss problems encountered and the solutions determined; to discuss the costs involved for construction, equipment and operation of the facility; and to promote the advantages of beneficial use of composted biosolids. Additional information concerning the facility and operation can be found at www.sanangelotexas.us/compost under the Kickapoo Composting Facility link.

KEYWORDS
Composting, no bulking material, anaerobically digested biosolids, Class A biosolids.

BACKGROUND INFORMATION

THE VISION

In the late 1990's the city began to research options available for the beneficial use of digested biosolids. This effort was driven by the increased cost of developing and operating landfills and the realization of the need to develop a long-term plan for effective solids management. Different types of facilities were researched and visited to determine the benefits and drawbacks to each operation. The process of composting seemed to offer the best alternative for our proposed operation. Around 2000, the city embarked on an $11,000,000 sludge improvement project for the water reclamation facility. At this time the city chose to address the entire aspect of sludge management and to "complete the circle of re-use" in its biosolids management. The goal of the facility was to produce Class A biosolids of 100% of the digested solids generated by the water reclamation facility. The facility has met its goal and all of the compost is being utilized on city owned lands including recreational areas.

Research of composting operations across the United States revealed that some facilities were composting biosolids without the use of bulking materials. These facilities are located in the arid to semi-arid regions of California, Colorado and New Mexico. "Bulkless" composting operations in Roswell and Las Cruces, New Mexico were contacted and readily shared information concerning their unique operations. A site visit to these facilities convinced city staff that the process could be successfully employed in West Texas.

On November 8, 2002 the City of San Angelo's Kickapoo Composting Facility was registered with the TCEQ's Municipal Solid Waste Division. To provide for maximum operational flexibility, the operation was registered with the option of composting with or without the use of bulking materials. All composting operations to date have been completed without the use of bulking materials and no plans have been made to alter the operations.

Composting was initiated in December 2003 upon completion of the improvement project at the water reclamation facility. To date, the facility has composted an average of 13,000 cubic yards annually. Finished product is a fine brown colored humus-like material. Once the material has passed all the testing required by the TCEQ, its use is unrestricted.

The success of this facility enables it to serve as a model for other facilities. The elimination of equipment such as grinders, screens and labor required to produce bulking material and subsequently remove it prior to distribution makes this process even more economically and practically attractive. The potential to utilize this operation at small wastewater treatment plants is very high due to the fact that these facilities will usually already own the equipment necessary for composting operations (a loader and dump truck).

To date, composting operations that do not utilize bulking materials have been limited to regions that have a limited supply of those materials. These areas are generally arid to semi-arid climates. Some traditional composting operations that are located in humid climates report that the limiting factor to their operations is a limited supply of bulking material. Pilot studies should be conducted in more humid climates to determine the full potential for this process or to determine if this process is limited by ambient atmospheric conditions.

This composting facility and its operation would not have been possible without the vision and encouragement of our Director, Will Wilde, PE and Assistant Director, Tom Kerr, PE. They provided city staff with the tools to complete this project in a manner that allows for operational flexibility and makes this project efficient and effective. This paper would not have been completed without the unrelenting encouragement of Mr. Kerr. We would also like to thank the Texas Commission on Environmental Quality (TCEQ) for their support of our operation.

LOCATION, LOCATION, LOCATION

In borrowing from that famous marketing slogan, “Location is everything”, one must carefully consider the location of a composting operation. A properly operated facility should not be a source of complaint for neighbors, however a neighborhood already “sensitive” to the operation of a treatment facility will have a higher probability of being vocal during the development of additional treatment processes. Utilizing area within the permitted area of a wastewater treatment plant has advantages. The main advantage is that the operation may be conducted under the facility’s existing wastewater permit. Another advantage is the proximity of the facility to its feedstock and the potential to share equipment. If a location is chosen outside of the plant’s permitted area, then the operation may require registration with the TCEQ’s Municipal Solid Waste Division. Both processes require very similar information. Of course all such questions should be directed to the TCEQ.

The Department of Water Utilities is fortunate that the City owns a large tract around the water reclamation facility. A portion of this land is permitted for the irrigation of effluent

from the water reclamation facility. The availability of property near the water reclamation facility, still within the plant's permitted area and away from developed areas, makes the location of the City's composting operation ideal. Another advantage to the location chosen is that the facility is located within earthen berms that aid in the retention and management of storm water.

Figure 1: Aerial View of Site.

THE FACILITY

The Kickapoo Composting Facility is situated on a 12 acre site (see Figure 1). Approximately 6.5 acres of the facility is the concrete working pad, the storm water retention pond accounts for approximately 0.85 acres and the remaining area is used for an administration building, berms and a buffer zone.

The concrete working surface is utilized for temporary storage of biosolids prior to processing into a windrow, for active windrow operations and for curing the compost. The area required to conduct each phase of the operation fluctuates throughout the year. At one time, the facility may contain a large amount of cured or curing windrows while the amount of active windrow area is less. At other times of the year the ratio will reverse.

In sizing the windrow portion of the facility, sufficient room should be allowed for the operation of equipment between the windrows. A conservative design will allow room for the material to be in the active windrow phase for approximately 30 days and 60 to 90 days in the curing phase. Additional room must be allotted for temporary storage of feedstock materials, loading of finished product and equipment maneuvering on-site.

SOURCE MATERIAL

Composting operations in Texas traditionally utilize some type of bulking material in the composting process. Bulking materials consist of a readily available wood or fibrous type material that usually requires processing prior to use. In most instances, the bulking material is removed from the finished product prior to distribution. Only a portion is used in the process and the larger pieces are removed by screening to be re-used later. The Kickapoo Facility is able to produce compost without the use of bulking materials. This greatly reduces the equipment and labor costs associated with the operation of the facility without affecting the quality of the final product. The success of this operation allows other facilities an economical option for solids management.

The only material utilized in the composting operation is anaerobically digested biosolids. This material is continually produced at the City's Water Reclamation Facility. Prior to leaving the plant, the biosolids are processed through belt presses to dewater the biosolids to a moisture content of approximately 80%. No other materials (other than water) are added to the windrows to complete the composting process. The facility is allowed to accept other materials, but none have been utilized to date.

COMMON MISCONCEPTIONS

The common misconception that the operation has been faced with is that composting without biosolids will not work or that the operation will not work effectively or without significant limitations and problems. One of the main reasons given was that the bulking material increases the porosity of the windrow which allows adequate amounts of oxygen to be supplied to the microorganisms. In over two years of operation, we have not found any significant limitations to the process. The operation has been conducted without nuisance conditions being a factor and in various climatic conditions (cold, wet periods along with hot, dry periods). However the most common response to our operation is that this couldn't possibly work. But the process does work and it works quite well and with greater efficiency and less cost than traditional bulking compost operations.

Cold weather combined with rain has been found to have the greatest potential to lower a windrow's temperature. This impact seems to be the greatest while the windrow is in its infancy. Once the windrow has established a temperature above 50°C, the impact was found to be less. To date, operations have not been halted due to weather conditions affecting the windrow temperatures. Composting operations were temporarily suspended due to an unusual abundance of rainfall that overloaded the original design of the storm water management plan. This situation will be discussed further in the "Start-up Challenges" section on page 7.

Due to the ease of the operation and the ability to compost without the necessity of locating, processing and handling bulking materials at a ratio of 2 to 3 times the amount of biosolids, the composting operation is greatly simplified. A significant advantage to simplifying the process is that composting becomes a more feasible option for biosolids management. Existing composting operations can also benefit. Composting operations that are not utilizing all of the available biosolids because of a lack of bulking materials may be able to expand their operations by implementing "bulkless" composting.

FACILITY OPERATIONS

THE COMPOSTING PROCESS

Composting is the natural transformation of organic material into a humus-like material. The composting process is completed by nematodes, protozoans, bacteria and fungi. The microbial breakdown of organic material produces heat as a by-product. The production of heat provides a simple means of monitoring the progression of the process. The U.S. Environmental Protection Agency defines composting as maintaining 55° C (131° F) for 15 days with 5 turnings. A benefit of the heat production is that pathogens, fly larvae and seeds are destroyed. Turnings ensure that all of the material is subject to the composting process and heat while also aerating the windrow to ensure an aerobic process. Operators must watch temperatures not only to ensure that temperatures are maintained but also to make sure that temperatures stay below 65-70° C. High temperature must be avoided to minimize the fire hazard and because most species of microorganisms cannot survive at these temperatures. Once the compost has passed through the required 15 day period, elevated temperatures can still be maintained by keeping the moisture content above 25%. Continuation of this process stabilizes organic material and results in a finished product that is "cured" and less likely to produce objectionable odors. Moisture content of the windrow seems to be the main factor in achieving and maintaining elevated temperatures. Once the temperature is established bulking and non-bulking operations seem to have few differences. See "Potential Applications and Studies" section (page 16) for a discussion on applications of bulkless composting operations .

The Kickapoo Composting Facility utilizes the aerated windrow method for composting. See Figure 2 for a diagram of the composting process. Class B anaerobically digested biosolids arrive at the compost facility with a moisture content of approximately 80%. Research revealed that aerobic composting requires a moisture content between 50% to 30%. Blending the incoming feedstock with finished compost was chosen as the method to adjust the moisture content and also seed the incoming material with the compost organisms. The facility constructs the windrows using a ratio of 1 part digested biosolids to 1 to 2 parts finished compost. This ratio varies based on the amount of finished compost available. See "Start-up Challenges" (page 7) for a discussion concerning other mixture ratios. Upon completion of the 15 day windrowing cycle, the finished (but not cured) compost typically has a moisture content of 30 to 40%. At the 1:1 blend ratio, approximately two-thirds of the volume of the windrow is moved to the curing area of the working pad while one-third of the windrow is left for use in mixing with incoming material. Compost placed in the curing area is still turned and temperature monitored for approximately 60 days. If temperatures decrease, water is added to maintain temperature. The curing windrows are usually turned once a week. At the end of the sixty day period, the moisture content is usually no greater than 20% and the material has achieved a fine dry consistency similar to soil. This curing time is not required by regulations but is an important part of the process as it allows the compost to mature. The regulatory testing is performed at the end of the sixty day period. Once testing is performed no water or any other materials are added to the windrow and the material is ready for distribution.

Once the material has completed the regulatory requirements for temperature, turnings, metal concentrations and pathogen reduction, it is classified as a Class A Biosolid. The use of Class A Biosolids is not restricted by location. The finished product makes an excellent soil conditioner. The compost improves soil quality by adding organic matter, nutrients and beneficial microorganisms. Compost also improves soil structure, porosity and water holding capacity. An additional benefit is obtained by the addition of a large number of various beneficial microorganism species and micro-arthropods. These organisms are especially beneficial in helping degraded or heavily eroded soils to recover and sustain plant life.

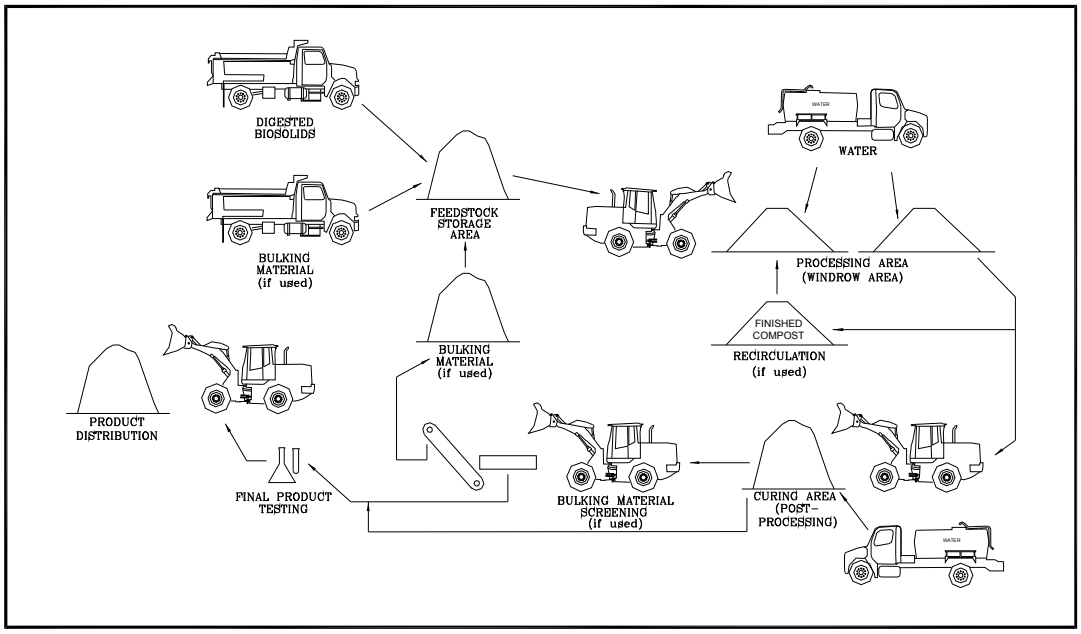

Figure 2: Process Diagram

START-UP CHALLANGES

Initial operations at the facility focused on finding a method to reduce the incoming feedstock's moisture content from 80% to approximately 50% or even lower. The method first utilized to lower the moisture content was to spread the biosolids out approximately 3 to 6 inches thick using the spreader trucks and rely on atmospheric drying. Moisture reduction was much slower than anticipated and lack of space quickly became the limiting factor. However, this method is a simple method that can be employed to facilitate start-up operations. Unless a facility has finished compost available for use to adjust the moisture content, a new facility will need to work up to its ultimate quantity as material becomes available for mixing with the incoming biosolids.

Once mixture of incoming biosolids with finished (but not cured) compost was determined to be the choice of moisture reduction, the natural question was what ratio would be the most effective for our operation and facility layout and size. To determine

Composting Cycle:

Date	Temp. #1 °C	Temp. #2 °C	Temp. #3 °C	Oper. Temp. °C	Moisture Content %	Fixed Solids %	Volatile Solids %	No. of Turns	Water Added Gallons
07/16/04	37	37	37	37	50.0%	48.0%	52.0%	4	
07/17/04	40	40	40	40					
07/18/04	39	39	39	39					
07/19/04	43	43	43	43	49.6%			2	
07/20/04	46	46	46	46					
07/21/04	47	47	47	47	45.9%			2	
07/22/04	48	48	48	48					
07/23/04	50	50	50	50					
07/24/04	51	51	51	51					
07/25/04	53	53	53	53					
07/26/04	52	52	52	52	44.7%			2	
07/27/04	47	47	47	47					
07/28/04	49	49	49	49					
07/29/04	50	50	50	50					
07/30/04	50	50	50	50	44.5%			2	
07/31/04	49	49	49	49					
08/01/04	51	51	51	51					
08/02/04	51	51	51	51	44.2%			2	
08/03/04	49	49	49	49					
08/04/04	54	54	54	54	43.7%			2	
08/05/04	56	56	56	56					
08/06/04	58	58	58	58	41.7%			2	
08/07/04	61	61	61	61					
08/08/04	65	65	65	65					
08/09/04	65	65	65	65					
08/10/04	65	65	65	65	38.8%			2	
08/11/04	62	62	62	62					
08/12/04	64	64	64	64					
08/13/04	62	62	62	62				2	
08/14/04	63	63	63	63					
08/15/04	63	63	63	63					
08/16/04	62	62	62	62	35.5%			2	
08/17/04	62	62	62	62					
08/18/04	66	66	66	66	34.7%			2	
08/19/04	64	64	64	64					
08/20/04	63	63	63	63	34.0%			2	
08/21/04	61	61	61	61					
08/22/04	63	63	63	63					
08/23/04	65	65	65	65	37.9%			2	
08/24/04	60	60	60	60					
08/25/04	64	64	64	64	32.5%			2	
08/26/04	62	62	62	62					
08/27/04	61	61	61	61	21.9%	59.2%	40.8%	2	
Min. Recorded Value:			37	37	22%	48%	41%	2	0
Max. Recorded Value:			66	66	50%	59%	52%	4	0

San Angelo Water Reclamation Facility
Compost Windrow Record:

Windrow Number:	20040716
Pad Location:	1
Construction Begin:	07/16/2004
Construction Complete:	07/16/2004
First Day at Temperature:	08/05/2004
Last Day at Temperature:	08/27/2004
Windrow Disposal Date:	08/27/2004

Windrow Construction:

Date	Belt Cake CY	Blend Stock CY	Daily Added CY	Cumm. Total CY
07/16/04	30	30	60	60

Final Disposition:

Description:	CY
Placed In Stock Pile:	
Placed in New Windrow:	35
Other:	
Total CY Finished:	35

Notes:

A 60 yd. windrow constructed on Friday, July 16, 2004 with a 1 to 1 blend of composted sludge and belt cake. The moisture content of the blended windrow is 50%. The composted feed sludge had a moisture content of 29% while the belt cake was at 76% moisture. This windrow and three others of similar size with varying blend ratios will be monitored to evaluate time to reach regulatory operating temperature. 07/26-07/27: Rain and cooler weather impacts moisture and temperatures. Rain Events 08/06-08/11.

Processing Time:

Days to Construct:	1
Days to Reach Temp.:	20
Days in Composting:	23
Total Days Processing:	43

Processing Volumes:

Total Belt Cake (CY):	30
Blend Stock (CY):	30
Processing Total (CY):	60
Final Compost (CY):	35

Processing Data / Statistics:

Total Compost Turnings:	34
Total Gallons of Water Added:	0
Total Volume Reduction:	42%
Days Greater Than Reg. Temp.:	23
Volatile Solids Reduction:	36%

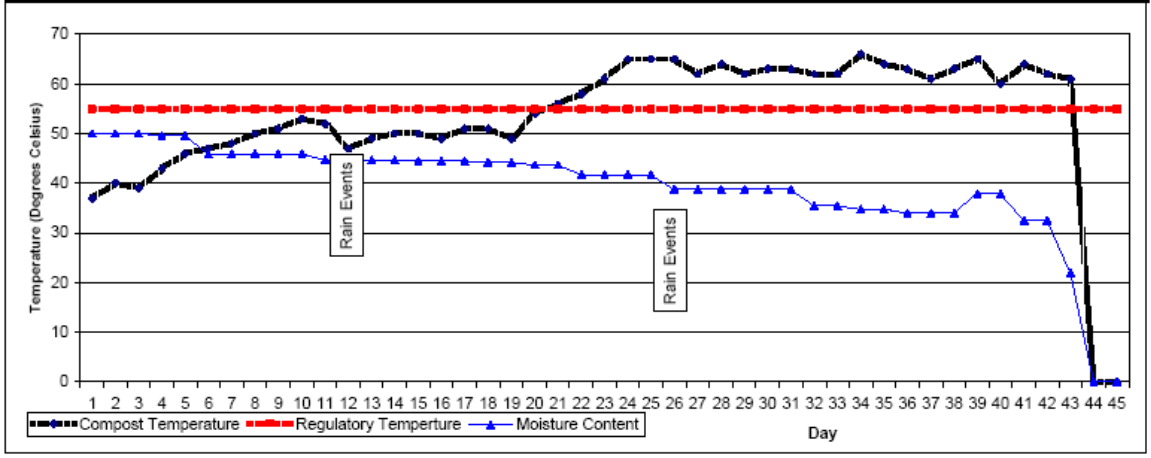

TABLE 1: 1 TO 1 BLEND RATIO

Composting Cycle:									
Date	Temp. #1 °C	Temp. #2 °C	Temp. #3 °C	Oper. Temp. °C	Moisture Content %	Fixed Solids %	Volatile Solids %	No. of Turns	Water Added Gallons
07/16/04	40	40	40	40	47.1%	50.7%	49.3%	4	
07/17/04	44	44	44	44					
07/18/04	41	41	41	41					
07/19/04	47	47	47	47	39.7%			2	
07/20/04	52	52	52	52					
07/21/04	52	52	52	52	39.6%			2	
07/22/04	55	55	55	55					
07/23/04	61	61	61	61					
07/24/04	62	62	62	62					
07/25/04	63	63	63	63					
07/26/04	63	63	63	63	38.7%			2	
07/27/04	55	55	55	55					
07/28/04	58	58	58	58					
07/29/04	62	62	62	62					
07/30/04	63	63	63	63	39.2%			2	
07/31/04	55	55	55	55					
08/01/04	55	55	55	55					
08/02/04	57	57	57	57	43.3%			2	
08/03/04	55	55	55	55					
08/04/04	60	60	60	60	40.2%			2	
08/05/04	62	62	62	62					
08/06/04	65	65	65	65	37.1%			2	
08/07/04	62	62	62	62					
08/08/04	68	68	68	68					
08/09/04	70	70	70	70					
08/10/04	68	68	68	68	34.7%			2	
08/11/04	66	66	66	66					
08/12/04	67	67	67	67					
08/13/04	65	65	65	65	33.6%	56.5%	43.6%	2	
08/14/04	65	65	65	65					
08/15/04	65	65	65	65					
08/16/04	65	65	65	65	31.6%			2	
08/17/04	63	63	63	63					
08/18/04	64	64	64	64	34.7%			2	
08/19/04	63	63	63	63					
08/20/04	65	65	65	65	30.5%			2	
08/21/04	63	63	63	63					
08/22/04	66	66	66	66					
08/23/04	62	62	62	62	26.3%			2	
08/24/04	55	55	55	55					
08/25/04	61	61	61	61	30.3%			2	
08/26/04	61	61	61	61					
08/27/04	60	60	60	60	27.7%			2	
Min. Recorded Value:			40	40	26%	51%	44%	2	0
Max. Recorded Value:			70	70	47%	56%	49%	4	0

San Angelo Water Reclamation Facility	
Compost Windrow Record:	
Windrow Number:	20040716
Pad Location:	2
Construction Begin:	07/16/2004
Construction Complete:	07/16/2004
First Day at Temperature:	07/22/2004
Last Day at Temperature:	08/27/2004
Windrow Disposal Date:	08/27/2004

Windrow Construction:

Date	Belt Cake CY	Blend Stock CY	Daily Added CY	Cumm. Total CY
07/16/04	21	42	63	63

Final Disposition:	
Description:	CY
Placed In Stock Pile:	
Placed in New Windrow:	35
Other:	
Total CY Finished:	35

Notes:

A 60 yd. windrow constructed on Friday, July 16, 2004 with a 2 to 1 blend of composted sludge and belt cake. The moisture content of the blended windrow is 47%. The composted feed sludge had a moisture content of 29% while the belt cake was at 76% moisture. This windrow and three others of similar size with varying blend ratios will be monitored to evaluate time to reach regulatory operating temperature. 07/26-07/27: Rain and cooler weather impact windrow temperature and moisture content.Rain Events 08/06-08/11.

Processing Time:	
Days to Construct:	1
Days to Reach Temp.:	6
Days in Composting:	37
Total Days Processing:	43

Processing Volumes:	
Total Belt Cake (CY):	21
Blend Stock (CY):	42
Processing Total (CY):	63
Final Compost (CY):	35

Processing Data / Statistics:	
Total Compost Turnings:	34
Total Gallons of Water Added:	0
Total Volume Reduction:	44%
Days Greater Than Reg. Temp.:	37
Volatile Solids Reduction:	21%

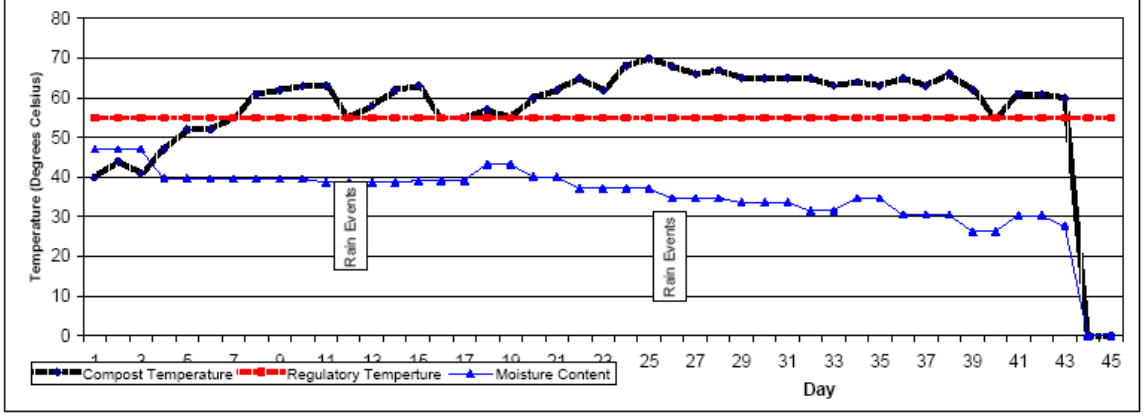

TABLE 2: 2 TO 1 BLEND RATIO

Composting Cycle:									
Date	Temp. #1 °C	Temp. #2 °C	Temp. #3 °C	Oper. Temp. °C	Moisture Content %	Fixed Solids %	Volatile Solids %	No. of Turns	Water Added Gallons
07/16/04	39	39	39	39	42.8%	52.0%	48.0%	4	
07/17/04	46	46	46	46					
07/18/04	46	46	46	46					
07/19/04	48	48	48	48	40.4%			2	
07/20/04	52	52	52	52					
07/21/04	52	52	52	52	35.3%			2	
07/22/04	56	56	56	56					
07/23/04	66	66	66	66					
07/24/04	67	67	67	67					
07/25/04	68	68	68	68					
07/26/04	67	67	67	67	37.3%			2	
07/27/04	55	55	55	55					
07/28/04	55	55	55	55					
07/29/04	63	63	63	63					
07/30/04	65	65	65	65	42.1%			2	
07/31/04	57	57	57	57					
08/01/04	59	59	59	59					
08/02/04	60	60	60	60	38.4%			2	
08/03/04	58	58	58	58					
08/04/04	67	67	67	67	36.8%			2	
08/05/04	66	66	66	66					
08/06/04	67	67	67	67	35.3%			2	
08/07/04	66	66	66	66					
08/08/04	69	69	69	69					
08/09/04	65	65	65	65					
08/10/04	70	70	70	70	34.6%			2	
08/11/04	62	62	62	62					
08/12/04	64	64	64	64					
08/13/04	66	66	66	66	31.7%	58.5%	41.5%	2	
08/14/04	68	68	68	68					
08/15/04	66	66	66	66					
08/16/04	67	67	67	67	31.7%			2	
08/17/04	61	61	61	61					
08/18/04	65	65	65	65	31.5%			2	
08/19/04	63	63	63	63					
08/20/04	65	65	65	65	31.1%			2	
08/21/04	65	65	65	65					
08/22/04	65	65	65	65					
08/23/04	63	63	63	63	31.7%			2	
08/24/04	57	57	57	57					
08/25/04	61	61	61	61	28.7%			2	
08/26/04	61	61	61	61					
08/27/04	60	60	60	60	27.6%			2	
Min. Recorded Value:			39	39	28%	52%	42%	2	0
Max. Recorded Value:			70	70	43%	59%	48%	4	0

San Angelo Water Reclamation Facility	
Compost Windrow Record:	
Windrow Number:	20040716
Pad Location:	3
Construction Begin:	07/16/2004
Construction Complete:	07/16/2004
First Day at Temperature:	07/22/2004
Last Day at Temperature:	08/27/2004
Windrow Disposal Date:	08/27/2004

Windrow Construction:

Date	Belt Cake CY	Blend Stock CY	Daily Added CY	Cumm. Total CY
07/16/04	15	45	60	60

Final Disposition:	
Description:	CY
Placed In Stock Pile:	
Placed in New Windrow:	32.5
Other:	
Total CY Finished:	32.5

Notes:

A 60 yd. windrow constructed on Friday, July 16, 2004 with a 3 to 1 blend of composted sludge and belt cake. The moisture content of the blended windrow is 43%. The composted feed sludge had a moisture content of 29% while the belt cake was at 76% moisture. This windrow and three others of similar size with varying blend ratios will be monitored to evaluate time to reach regulatory operating temperature. 07/26-07/27: Rain and cooler weather impact temperature and moisture content of windrow. Rain Events 08/06-08/11.

Processing Time:	
Days to Construct:	1
Days to Reach Temp.:	6
Days in Composting:	37
Total Days Processing:	43

Processing Volumes:	
Total Belt Cake (CY):	15
Blend Stock (CY):	45
Processing Total (CY):	60
Final Compost (CY):	32.5

Processing Data / Statistics:	
Total Compost Turnings:	34
Total Gallons of Water Added:	0
Total Volume Reduction:	46%
Days Greater Than Reg. Temp.:	37
Volatile Solids Reduction:	23%

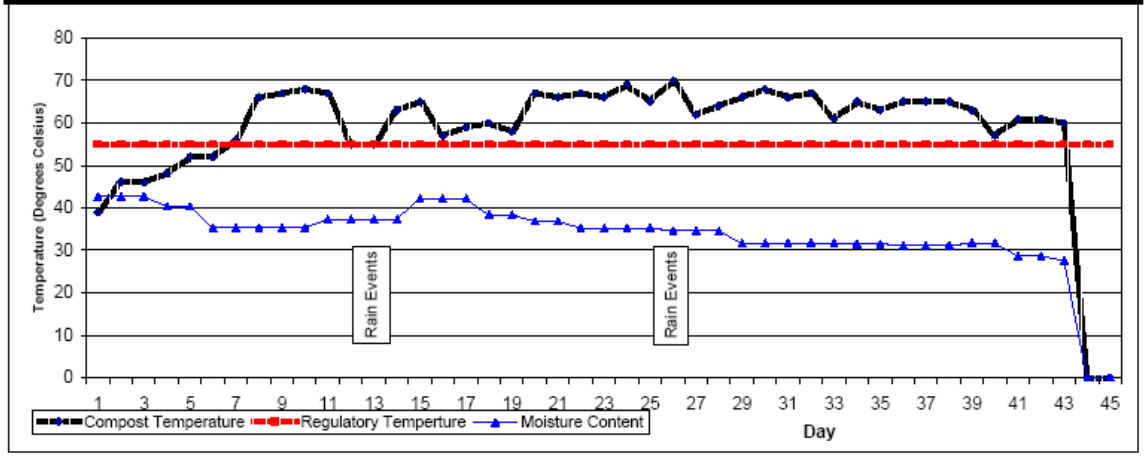

TABLE 3: 3 TO 1 BLEND RATIO

Composting Cycle:

Date	Temp. #1 °C	Temp. #2 °C	Temp. #3 °C	Oper. Temp. °C	Moisture Content %	Fixed Solids %	Volatile Solids %	No. of Turns	Water Added Gallons
07/16/04	39	39	39	39	39.1%	52.8%	47.2%	4	
07/17/04	48	48	48	48					
07/18/04	46	46	46	46					
07/19/04	51	51	51	51	37.5%			2	
07/20/04	56	56	56	56					
07/21/04	57	57	57	57	33.3%			2	
07/22/04	59	59	59	59					
07/23/04	66	66	66	66					
07/24/04	67	67	67	67					
07/25/04	67	67	67	67					
07/26/04	68	68	68	68	34.9%			2	
07/27/04	55	55	55	55					
07/28/04	55	55	55	55					
07/29/04	60	60	60	60					
07/30/04	63	63	63	63	38.4%			2	
07/31/04	55	55	55	55					
08/01/04	56	56	56	56					
08/02/04	60	60	60	60	37.3%			2	
08/03/04	59	59	59	59					
08/04/04	69	69	69	69	35.8%			2	
08/05/04	66	66	66	66					
08/06/04	65	65	65	65	30.5%			2	
08/07/04	64	64	64	64					
08/08/04	63	63	63	63					
08/09/04	60	60	60	60					
08/10/04	62	62	62	62	32.7%			2	
08/11/04	55	55	55	55					
08/12/04	62	62	62	62					
08/13/04	67	67	67	67	29.2%	59.2%	40.8%	2	
08/14/04	67	67	67	67					
08/15/04	70	70	70	70					
08/16/04	66	66	66	66	29.9%			2	
08/17/04	63	63	63	63					
08/18/04	70	70	70	70	29.6%			2	
08/19/04	64	64	64	64					
08/20/04	70	70	70	70	29.3%			2	
08/21/04	67	67	67	67					
08/22/04	68	68	68	68					
08/23/04	66	66	66	66	29.4%			2	
08/24/04	61	61	61	61					
08/25/04	66	66	66	66	26.7%			2	
08/26/04	63	63	63	63					
08/27/04	60	60	60	60	27.2%			2	
Min. Recorded Value:			39	39	27%	53%	41%	2	0
Max. Recorded Value:			70	70	39%	59%	47%	4	0

San Angelo Water Reclamation Facility
Compost Windrow Record:

Windrow Number:	20040716
Pad Location:	4
Construction Begin:	07/16/2004
Construction Complete:	07/16/2004
First Day at Temperature:	07/20/2004
Last Day at Temperature:	08/27/2004
Windrow Disposal Date:	08/27/2004

Windrow Construction:

Date	Belt Cake CY	Blend Stock CY	Daily Added CY	Cumm. Total CY
07/16/04	12	48	60	60

Final Disposition:

Description:	CY
Placed In Stock Pile:	
Placed in New Windrow:	25
Other:	
Total CY Finished:	25

Notes:

A 60 yd. windrow constructed on Friday, July 16, 2004 with a 4 to 1 blend of composted sludges and belt cake. The moisture content of the blended windrow is 39%. The composted feed sludge had a moisture content of 29% while the belt cake was at 76% moisture. This windrow and three others of similar size with varying blend ratios will be monitored to evaluate time to reach regulatory operating temperature. 07/26-07/27: Rain and cooler weather impact windrow temperature and moisture content. Rain Events 08/06-08/11.

Processing Time:

Days to Construct:	1
Days to Reach Temp.:	4
Days in Composting:	39
Total Days Processing:	43

Processing Volumes:

Total Belt Cake (CY):	12
Blend Stock (CY):	48
Processing Total (CY):	60
Final Compost (CY):	25

Processing Data / Statistics:

Total Compost Turnings:	34
Total Gallons of Water Added:	0
Total Volume Reduction:	58%
Days Greater Than Reg. Temp.:	39
Volatile Solids Reduction:	23%

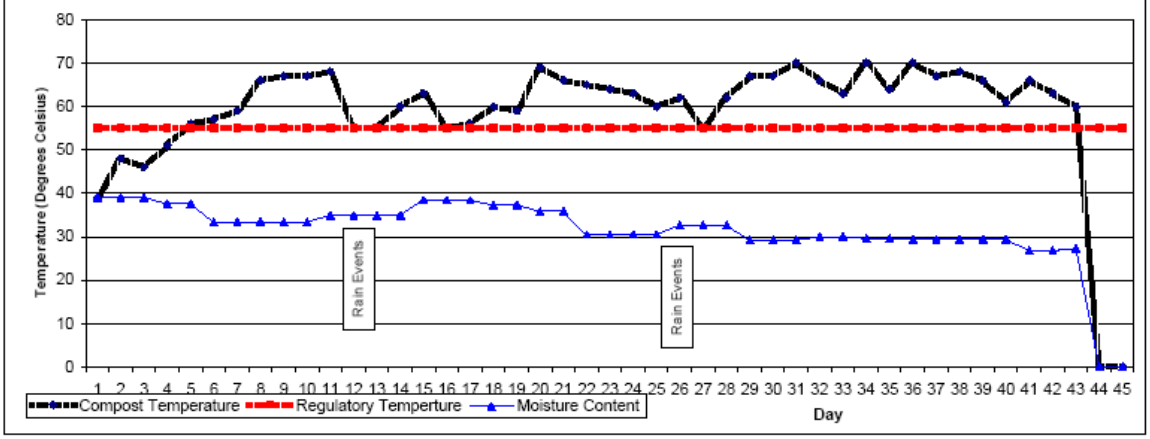

TABLE 4: 4 TO 1 BLEND RATIO

this, four experimental rows were formed. Each windrow contained a total of approximately 60 cubic yards. The blend ratios of finished compost to anaerobically digested biosolids were set at 1:1, 2:1, 3:1 and 4:1, respectively. Results are shown in Tables 2, 3, 4 and 5. The Blend ratio of 1:1 was found to reach the minimum regulatory temperature of 55°C in 20 days while the 2:1 and 3:1 reached temperature in 6 days and the 4:1 reached temperature in 4 days. Clearly there is no practical advantage gained by exceeding a ratio of 2:1 in the conditions encountered during our experiment. However a significant reduction in time required to reach minimum temperature is seen the 1:1 and 2:1 mixtures. In evaluating the blend ratio to be utilized, one must remember that even at the 1:1 ratio twice as much material must be handled and at 2:1 three times as much material will be on-site during for the process. Therefore in evaluating the space available for composting, the layout of the facility and the amount of material that must be handled, the ratio of 1:1 was initially chosen for our facility. Once the facility's output reached a point that larger amounts of finished compost became available, personnel have varied the blend ratio from 1:1 to 1:2 and have seen a significant decrease in the amount of time required for the windrows to reach the minimum regulatory temperature.

Operations have shown that it takes an average of 14 days for the 1:1 windrows to reach temperature. Windrows have been observed to reach temperature as quickly as 3 days after construction and as many as 20 days after construction. Ambient weather conditions seem to be the largest outside influence (not counting moisture content) on the amount of time required to reach minimum temperature.

Other factors that must be considered in determining a mixture ratio are the development or potential of nuisance conditions. Utilizing a 1:1 ratio has not produced any vector attraction (flies, gnats, other flying insects, etc.) or nuisance conditions (odors, dust, etc.). The largest potential for the development of these conditions exists with the incoming feedstock due to its high moisture content (approximately 80%). This material should be dried or mixed into a windrow as soon as possible to prevent the development of nuisance conditions.

The facility's storm water handling system was originally designed under the assumption that more water would be required to maintain windrow moisture contents than was found to be required in actual operations. The low use of water combined with a series of one to two inch rainfall events followed by an usually large rainfall event (approximately 6 inches of rain in a two week period) temporarily halted composting operations until a pump and pipeline could be installed to transport excess storm water to the head of the water reclamation facility. This situation is the only time that composting operations were suspended since operations began in December 2003.

RECORD KEEPING AND TCEQ REPORTING

City staff developed the worksheet shown in Tables 1 through 4. The worksheet generates a unique identifying number for each windrow based on the date of construction of the windrow. The content, size and ratio of the windrow's make-up are recorded along with its final disposition. The worksheet also contains an area to enter the daily temperature recordings, the moisture content, the percent fixed and volatile solids,

the number of turnings and the amount of water added. In order to provide a quick visual summary of the progress of the windrow, a graph is attached to the bottom of the sheet. This graph automatically tracks the temperature and moisture content values as they are entered into the worksheet. This provides an instantaneous visual reference to the state of the windrow. The graph also displays the minimum regulatory temperature of 55°C.

The TCEQ requires that the following records be maintained for a minimum of five years:

- Concentration of each metal listed in 30 TAC 312.43(b)(3) Table 3.
- Description of how the Class A pathogen requirements in 30 TAC 312.82(a) are met.
- Description of how one of the vector attraction reduction requirements in 30 TAC 312.83(b)(1) through (8) is met.
- Documentation that the annual whole sludge application rate does not exceed the loading rates established in 30 TAC 312.43(b)(4) Table 4.
- Signed certification statement.

An annual report must be submitted to TCEQ that contains the following information:

- Results of metal testing from 30 TAC 312.43(b)(3) Table 3.
- The frequency of monitoring.
- Toxicity Characteristic Leaching Procedure (TCLP) test results.
- PCB concentration in feedstock.
- Documentation of achievement of Class A status.
- Description of how Class A pathogen reduction requirements were met.
- Description of how vector attraction reduction was met.
- Annual biosolids production.
- Amount of finished product land applied.
- Signed certification statement.

The required records and reporting requirements are not as daunting as they may first seem. When compared to the record keeping and reporting requirements for the operation of a wastewater treatment plant and for the disposal of its digested biosolids in a landfill, these requirements do not really represent a significant increase over the amount of effort that is already being expended. Some of the above requirements will already be recorded or required for most biosolids handling activities.

EFFICIENT PROCESS EQUALS MORE POTENTIAL APPLICATIONS

Bulkless composting is an efficient process not so much because of what is done but because of what is not done or needed. The real advantage to bulkless composting is in its simplicity. Less equipment, operating space and personnel are needed to process less material than in traditional composting operations. An additional benefit is that the facility is not dependent on any outside sources for its feedstock material.

Elimination of the need for bulking materials results in this process being a more economically feasible alternative for the production of Class A biosolids. Promotion of this process will allow communities the opportunity to save valuable landfill space while benefiting the environment through the safe reuse of biosolids.

One example of a plant utilizing existing equipment would be in the case of a facility that has the ability to utilize one of its sludge drying beds for composting operations. Generally these facilities are small and are located in arid to semi-arid regions. A common challenge for small facilities is the availability of capital for improvement projects. Since most of these facilities already utilize a loader and dump truck to handle their sludge, this equipment could be used to form a windrow and turn the material. As will be shown later, the diversion of material from disposal in a landfill has an economic benefit. This benefit will be realized immediately for facilities that are charged for disposal of their sludge.

STAFF

Operational staff includes a compost manager, two compost technicians and two truck drivers. One technician is part-time. He shares duties at the compost facility and another city department. None of the facility's staff had any prior experience in large scale compost operations. However, their dedication, perseverance and ingenuity has made this operation a success.

Nuisance conditions such as odor and vector attraction are best prevented by the establishment and consistent implementation of good operational procedures. Composting is accomplished by living organisms. Therefore the operators must learn how the windrows react to changes in the feedstock, changes in the mixture recipe, changes in moisture content, changes in atmospheric conditions (hot dry wind, rain, cold, etc) and even changes in operational procedures. Fortunately these organisms are forgiving and relatively easy to work with. For instance, if the temperature falls and the moisture content is low, water can be added and the microorganisms will respond very quickly as evidenced by the increased temperatures.

EQUIPMENT

The facility utilizes dump trucks to transport feedstock to the facility for processing. This equipment was previously utilized to transport the digested sludge to the City's landfill. Upon arrival at the facility a wheel loader with a 3.5 cubic yard bucket builds the windrows by mixing finished compost with the digested sludge at the ratio of 1:1 to 1:2. Mixing of the windrows is accomplished by a self-propelled tunnel type compost turner. The turner is sized for a maximum windrow width of 16 feet and a maximum height of 6 feet. As needed, a 1500 gallon water truck provides water to the windrows. Depending on the end-user's requirements, either the traditional dump trucks or the spreader/dump trucks are used to deliver the product. If the material is sold or given away in the future, then most likely the individual's equipment will be loaded at the site. In the event that the compost turner is not operational, the wheel loader serves as a back-up. If conditions warrant the need to temporarily suspend operations, then the digested sludge can still be taken to the City's landfill.

COST BENEFIT ANALYSIS

The following cost benefit analysis compares the cost of constructing, equipping and operating a bulkless composting operation, a composting operation that utilizes bulking material and the cost of disposal of the biosolids in the local landfill.

Description	Capital Expense	Life Expectancy (years)	Annual Cost	Total Cost per Ton
BULKLESS COMPOSTING FACILITY				
Facility Improvements (Earthwork, Concrete, Storm Water Pond, etc.)	$900,000	50	$49,300	-
Equipment (Compost Turner, Wheel Loader, Two Spreader Dump Trucks, Water Truck)	$350,000	10	$58,300	-
Annual Operation & Maintenance (4 Full-Time, 1 Part-Time Employees, Material Testing, etc.)	na	na	$138,000	-
TOTAL ANNUAL COSTS BULKLESS:			**$245,600**	**$20.14**
COMPOSTING WITH BULKING MATERIALS (adders to above)				
Additional Facility Improvements (more space required)	$300,000	50	$16,400	-
Additional Equipment (Grinder & Screen)	$354,000	10	$45,800	-
Additional Annual Operation & Maintenance (Labor & Equipment)	na	na	$35,000	-
TOTAL ANNUAL COSTS WITH BULKING MATERIAL:			**$342,800**	**$28.98**
Potential Revenue, Common to Both Composting Operations ($10/ yd^3 at 2,400 yd^3/yr)	na	na	**$24,000**	-
BIOSOLIDS DISPOSAL COSTS				
Disposal Costs (Landfill charge of $23.58/ton)	na	na	$260,000	-
Equipment (Transportation to Landfill)	$110,000	10	$14,200	-
Annual Operation & Maintenance	na	na	$7,000	-
TOTAL ANNUAL DISPOSAL COSTS:			**$281,200**	**$25.56**

Table 5: Cost Benefit Analysis and Comparison

The capital expenses were amortized using an annual percentage rate of 5% to obtain an annual cost. The costs shown for a composting operation that utilizes bulking material are costs that would be required in addition to the costs shown for the bulkless composting operation. Both composting operations receive the same benefit from the potential sale of finished product and the total cost per ton reflects this advantage. Since operations began approximately 13,000 cubic yards (approximately 11,000 wet tons) of material has been diverted from disposal at the City's landfill. This number is the basis for determining the cost per ton. Biosolids disposal costs were determined using the landfill's current charge of $23.58 per ton in addition to equipment and operational cost to transport the material. The above analysis demonstrates that the bulkless composting operation is more cost effective than either a bulking compost operation or disposal in a landfill.

POTENTIAL APPLICATIONS AND STUDIES

To date, composting operations that do not utilize bulking materials have been limited to regions that have a limited supply of those materials. These areas are generally arid to semi-arid climates. Pilot studies should be conducted in more humid climates to determine the full potential for this process or to determine if this process is limited by ambient atmospheric conditions. As has been discussed, even regions that have large potential sources of bulking material may not be able to produce enough bulking material to compost all of the biosolids produced at their wastewater treatment plant. The adoption of a bulkless composting process would provide the facility with all of the benefits already discussed.

CLOSING

The success of this project has been determined by the following:

- Relative ease of the operation
- Less equipment, space and personnel required
- Minimal nuisance conditions (odors, vectors, etc.)
- Acceptance of final product by others
- Diversion of 100% of biosolids from disposal in the landfill (approximately 13,000 cubic yards)
- Potential source of revenue from a previously unmarketable material
- Potential application of process to other facilities
- Economic alternative for beneficial re-use of biosolids

The city is actively seeking opportunities to publicly outline the benefits of composting without bulking materials; to discuss problems encountered and solutions determined during facility start-up; and to promote the beneficial use of composted biosolids. The city's website (**www.sanangelotexas.us/compost**) has been designed as an outreach to all interested parties.

Current regulations allow for the disposal of biosolids at municipal solid waste facilities or land application if certain conditions are met. However by employing a relatively simple process, the material can be transformed into a valuable product that is virtually unrestricted in use. To date, the city has utilized all of the compost on city parks but the potential exists for marketing the material to further offset operational costs. Irregardless of the ultimate application, the biosolids are utilized in a beneficial way instead of being disposed of in a landfill.

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- Mr. Art Torres, City of Roswell, New Mexico
- Mr. Jody Slagle, PE, City of Austin

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