

White Paper
Land Application of
TerraNew Plant Nutrients

Written by

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INTRODUCTION

One of the greatest lessons to be learned from the last century is that all the earth's resources are limited and need to be judiciously managed, reused and recycled for maximum productivity and minimum adverse impact on our environment. The increasing population and resultant size of metropolitan areas has proven problematic when approached from a waste disposal viewpoint. However, sorting and recycling refuse and composting green and food waste have significantly reduced solid waste disposal in many communities. In some locations, biosolids from sewage treatment plants, after some initial treatment, have been diverted for beneficial use either as a constituent in compost or directly land applied. Use of biosolids as a fuel to drive energy-producing anaerobic digesters prior to use as soil amendment and nutrient source in land application squeezes yet more utility from what was previously considered merely a waste product. The land application of biosolids or other waste from sewage treatment or food processing facilities is a proven way to recycle nutrients and carbon from waste to useful inputs without loading either the atmosphere or water bodies. Such processes make sense, both environmentally and economically.

THE TerraNew PROCESS

TerraNew has developed a process by which many types of semi-solid (5-10% solid) waste streams have been economically converted into a safe, easy-to-manage liquid nutrient or soil amendment suitable for use in practically any cropping system. The TerraNew process involves a grinding step to reduce the size of particulates for quick reaction; this is followed by a heating process and then a reaction phase where acids and oxygen are added and heat is generated. The reaction does not completely digest the waste into basic elements, but enough heat and acid are involved to sterilize the waste stream and generate a liquid that is easily pumped and handled. Wastes from food processing (sugar cane) and biosolids and side-stream sources from sewage treatment plants have been successfully treated in the TerraNew process.

The product of the TerraNew process is called ZeFluent™. Because the product is a result of sewage treatment, state and federal regulations control land application. Thus far, ZeFluent derived from state of Utah biosolids has been land applied. A rancher-cooperator in Mount Pleasant, Utah has allowed the application of the ZeFluent™ to a few hay fields over the years of development of the TerraNew process.

The ZeFluent™, as a result of the addition of nitric acid, sulfuric acid and aqueous ammonia during the process, has greater plant nutrient value than the original biosolids. That, in conjunction with the safety and ease of handling of the finished product, makes ZeFluent more attractive for agricultural applications than either Class A or Class B biosolids.

LAND APPLICATION GUIDANCE

There are several hurdles to be overcome before biosolids can be safely and legally land-applied. In 1993 as a result of the Clean Water Act of 1987, “The Standards for the Use and Disposal of Sewage Sludge” (Title 40 of the Code of Federal Regulations [CFR], part 503) became effective. Minor amendments were adopted to the 503 rule in 1994. The 503 regulations represent the first layer of control for the land application of biosolids. Further, state and local governments may impose additional mandates on the land application of biosolids (rf. Utah Administrative Code R317-1-6. Disposal of Domestic Wastewater Treatment Works Sludge). The state of Utah requires a Utah Pollutant Discharge Elimination System (UPDES) permit for land disposal of treated sewage sludge, and further requirements may be written into each permit. Federal 503 regulations are discussed in this document as states most commonly (including Utah) defer to the guidelines contained therein; however, state and local requirements must be ascertained prior to instituting any biosolids land-application program. Whatever the presiding authority, land-application activities must be based on allowed pollution and nutrient limits, pathogen reduction and vector attraction reduction.

Pathogen Reduction

Public safety is of primary concern in all aspects of the land application of biosolids. The 503 rules contain very specific guidelines to safeguard the public from exposure to human pathogens as a result of land application. Two classes of biosolids, A and B, are defined based on treatment to reduce pathogens, and the handling of the different classes of biosolids differs based on the pathogen level. Table 1 below summarizes the options for biosolids treatment to achieve either a Class A or Class B determination. The method employed by TerraNew to confirm compliance with pathogens is highlighted in bold type.

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TABLE 1. PATHOGEN REDUCTION REQUIREMENTS	
CLASS A	
No Limitations on crops, grazing & public access	
1 or 2 or 3 or 4 or 5 or 6 AND 7	Fecal Coliform <1000 mpn/g - or - Salmonella <3 mpn/4g Meet temp/time treatment pH > 12 for 72 hrs, temp > 52C & dry < 50% solids enteric virus < 1 pfu/g And helminth ova < 1 /4g PFRP - Appendix B PFRP - Permitting Authority Meet vector attraction reduction (table 2 below)
CLASS B	
Various Limitations on crops, grazing & public access	
1 2 3	Fecal Coliform < 2,000,000 mpn/g PSRP - Appendix B PSRP - Permitting Authority

Notes: PFRP = Process to Further Reduce Pathogens, PSRP = Process to Significantly Reduce Pathogens

Note also in Table 1 that the treatment options for Class A biosolids do not include reducing the pH to <2. Historical sewage treatment has involved the use of quicklime, which raises pH to reduce pathogens. The monitoring of pH was used to ensure adequate lime had been added. No current commercial sewage treatment has yet utilized acid to reduce pH for the reduction of pathogens.

Vector Attraction Reduction (VAR)

A vector is any organism that can be attracted by and come in contact with the biosolids and pose a hazard of transmitting any contained pathogens to humans, either physically or biologically, by participating in or sustaining the pathogen life cycle. By their nature, biosolids contain carbon compounds that could represent food sources for various insects, arthropods, rodents and birds. These animals in turn could potentially act as vectors to disperse any pathogens contained in the biosolids. The 503 rules specify certain procedures by which the vector attraction of biosolids can be measured and thereby demonstrate a reduction in attraction due to process(es) employed. Biosolids are typically treated by some form of oxidative or reductive process to reduce the mass of carbon solids, to reduce odors, and to reduce the available food source, all of which could attract vectors. Table 2 below summarizes the vector attraction reduction requirements posed in the 503 rules. The method employed by TerraNew to confirm compliance with VAR is highlighted in bold type.

**TABLE 2. VECTOR ATTRACTION REDUCTION REQUIREMENTS FOR
LAND APPLICATION OF BIOSOLIDS**

1	Volatile Solid (VS) Reduction by 38%
or 2	VS Reduction of 40 day test post anaerobic treatment <17%
or 3	VS Reduction of 30 day test post aerobic treatment <15%
or 4	SOUR <1.5 mg/hour-g (dry wt.)
or 5	Aerobic process: 14 day with temp ≥ 40 C
or 6	Alkali addition to pH>12 for 2 hours & 11.5 for 22 hours
or 7	< 25% Primary sewage sludge solids prior to mixing
or 8	$\geq 90\%$ Primary sewage sludge solids prior to mixing
or 9	Sludge injected below the soil surface with no sludge present on surface after 1 hour of injection and to remain Class A, injected within 8 hours of pathogen treatment
or 10	Surface applied & incorporated within 6 hours or per permitting authority to remain Class A, injected within 8 hours of pathogen treatment
or 11	Covered with soil at day's end when applied to active sludge unit
or 12	Septage pH to be raised to 12 for 30 min prior to application

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Pollutant Limits

The 503 rules contain a table of heavy metal pollutant limits that were developed through a risk-based assessment. That table is reproduced as Table 3 in this document.

TABLE 3. 503.13 POLLUTANT LIMITS FOR LAND APPLICATION OF BIOSOLIDS				
Pollutant	Ceiling	Cumulative	Pollutant Monthly	Pollutant Annual
	Concentration	Pollutant Loading Rates	Average Concentration	Pollutant Loading Rate
	<u>mg/kg¹</u>	<u>kg/ha</u>	<u>mg/kg¹</u>	<u>kg/ha-365 days</u>
Arsenic	75	41	41	2
Cadmium	85	39	39	1.9
Copper	4300	1500	1500	75
Lead	840	300	300	15
Mercury	57	17	17	0.85
Molybdenum	75	--- ²	--- ²	--- ²
Nickel	420	420	420	21
Selenium	100	100	100	5
Zinc	7500	2800	2800	140

¹Dry weight basis.

² All but the ceiling limits for molybdenum were deleted in the 1994 amendments to the rule.

Monitoring and Record Keeping

The monitoring frequency of the biosolids, as mandated by the 503 regulations, depends upon the quantity being produced. Depending on production, facilities may need to monitor anywhere from once per year to once per month. Monitoring must include pathogen levels, vector attraction reduction and heavy metal concentrations.

Biosolids of lesser quality require varying degrees of record keeping, depending on pathogen treatment and heavy metal concentrations. Biosolids not meeting Class A or vector attraction reduction requirements have limits on where and how they may be applied. Those exceeding the “Ceiling Concentration Limit” (column 1 in Table 3) for any 1 or more metals may not be land applied. Biosolids with metal concentrations less than the “Ceiling” but more than the Pollution Concentration Limit for any one or more metals may be land applied, but a permit is required for each application site, and records must be maintained to ensure that total applications do not exceed the annual loading rate (column 4 in Table 3) or the Cumulative Pollutant Loading Rate (column 2 in Table 3) for any one or more of the metals.

Exceptional Quality (EQ) Designation

For biosolids meeting the Exceptional Quality (EQ) criteria, application records are generally not required to be maintained. The controlling authority, either state or federal, may impose reporting requirements as determined on a case-by-case basis. To meet EQ, three criteria must be met 1) pathogen reduction must meet Class A standards, 2) one of the first 8 vector attraction reduction procedures must be met and 3) heavy metal concentrations must be below the Pollution Concentration Limits (average monthly concentrations in column 3 of Table 3).

TerraNew Processed Biosolids and Side Streams are Exceptional Quality (EQ)

The TerraNew technology eliminates pathogens using temperatures at 165 degrees Celsius. (Please refer to the TerraNew white paper that explains about pathogens and the TerraNew process.) The TerraNew process also produces a product that complies with vector attraction reduction by using option number four (Table 2), which is the Specific Oxygen Uptake Rate (SOUR). Further, TerraNew tests for heavy metals per the regulations to ensure compliance with the pollutant concentration limits of Table 3 of Section 503.13 (Table 3 in this document).

For ease of reference, *The Environmental Regulations and Technology, Control of Pathogens and Vector Attraction in Sewage Sludge*, EPA/625/R-92/013, Revised July 2003, also known as the “White House Document” is quoted below.

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“Exceptional Quality (EQ) Biosolids - The term ‘EQ’ is not used in the Part 503 regulation, but it has become a useful description for regulators and biosolids preparers when referring to biosolids that meet the pollutant concentration limits of Table 3 of Section 503.13, Class A pathogen reduction, and one of the first eight treatment processes for meeting vector attraction reduction standards. Biosolids that fall into this category are not subject to the Part 503 general requirements and management practices for land application.”

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“Exceptional quality (EQ) biosolids are biosolids which have met the Part 503 pollutant concentration limits (Table 3 of Section 503.13) as well as Class A pathogen reduction requirements and one of the first eight vector attraction reduction options listed in 503.33(b)(1) through (b)(8). EQ biosolids may be land applied without site restrictions.”

Agronomic Rate

The land treatment process is designed to recycle valuable nutrients found in sewage or other waste streams. Consequently, it is important to know the nutrient concentrations in the biosolids,

the nutrient levels in the soil to which the biosolids are to be applied, and the nutrient requirements of the crop to be produced on the land. As long as the metals are below the Pollution Concentration Limit, the biosolids application rate for ZeFluent is determined by either the nitrogen or phosphorus requirement of the soil and the crop. This is because N and P are the dominant plant nutrients in ZeFluent. To determine the application rate, a worksheet is developed for each application field in which the nutrient loading rate for nitrogen and phosphorus is calculated based upon the volume of effluent applied, the acres to which it is to be applied, and the laboratory analysis of the effluent. The nutrient requirement is calculated for each application field based on the crop to be grown and the soil nutrient reserves. The application rate is calculated so that the total nutrients supplied by the biosolids application(s) in combination with other fertilizer sources or residual soil nutrient availability does not exceed nutrient requirements of the crop for that season or for the buildup of soil phosphorus levels.

In any nutrient application, including ZeFluent, best management practices (BMPs) should be established and followed to ensure applications meet the following criteria:

1. Nutrient applications do not exceed the agronomic nutrient requirement of the crop and/or desired soil buildup.
2. Nutrient applications are not made at a time of year or under conditions when runoff may result in loss of applied nutrients from the intended site of application.
3. Nutrient applications are made using appropriate and calibrated equipment so that applications are reasonably uniform and accurate.
4. A 33-foot buffer strip of no application will be maintained near streams, ponds, wetlands or ditches draining into streams or ponds (surface waters).

SUMMARY

The product of the TerraNew sewage treatment process meets the Exceptional Quality designation. ZeFluent has been demonstrated to be safe and easy to handle with no offensive odor. It is a liquid that is easy to transport and apply to agricultural fields and is dilute enough that no leaf damage is experienced with direct application to a growing crop. The ZeFluent, as a result of the addition of nitrogen and sulfur during the process, has greater plant nutrient value than the original biosolids.

The mission of TerraNew in the conversion of sewage sludge to ZeFluent is not to compete in the agricultural fertilizer industry. The mission is to solve a solid waste problem in the wastewater treatment industry and to recycle valuable crop nutrients and carbon in a convenient, safe and economical manner. ZeFluent is not intended to be the sole source of plant nutrients but to supplement existing resources in a farmer's nutrient management plan. TerraNew has undertaken limited field investigations and is cooperating with Utah State University to pursue a better understanding of the properties of ZeFluent and the most beneficial ways to utilize it on field crops.

References:

Electronic Code of Federal Register, Title 40. http://www.ecfr.gov/cgi-bin/text-idx?gp=&SID=068e3d020b3ad135093c0ae2bcf4a571&mc=true&tpl=/ecfrbrowse/Title40/40tab_02.tpl

Utah Administrative Code, TITLE R317. ENVIRONMENTAL QUALITY, WATER QUALITY, Rule R317-8. Utah Pollutant Discharge Elimination System (UPDES). <http://www.rules.utah.gov/publicat/code/r317/r317-008.htm>

For further information, please refer to these additional white papers on our web site:

Exceptional Quality and the TerraNew Process and
Side Streams, Nutrient Recovery and the TerraNew Process

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