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Reusing a Resource

Sludge Application to Croplands, Forests and Mined Lands Makes Sense

"Thanks to human fertilization, the earth in China is still as young as in the days of Abraham . . . All the human and animal manure which the world loses, restored to the land instead of being thrown into the water, would suffice to nourish the world." From Victor Hugo, Les Miserables (1862)

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The concept of utilizing human wastes to condition and fertilize soils extends back to ancient times. References to the use of wastes in agriculture can even be found in the Bible.

Now there is renewed interest in applying wastewater sludges (treated solid wastes) to Texas farmland and in composting sludges for use in landscaping. In the future, sludges may be applied to forests and mined lands.

The bottom line is clear: using sludges as a resource can benefit agriculture, cities and consumers.

Texas is producing a considerable amount of sludge. In 1980 400,000 dry tons were produced containing nutrients that could provide 150 pounds of nitrogen to more than 65,000 acres (Carlile, 1986).

As more advanced treatment is required, sludge production is predicted to double by the year 2000. Handling costs are also significant: sludge management accounts for 3040% of capital costs and 50% of operating costs at major wastewater treatment plants (Carlile, 1986).

Sludges are being applied to farmland in much of Texas and roughly 63,000 acres are registered with the Texas Department of Health (TDH) as application sites (Figure 1). The Environmental Protection Agency (EPA) estimated that in 1986 more than 210,500 acres of farmland in the U.S. received municipal sludges.

Composts, a mix of sludge, sawdust, and wood chips, are being produced in many of Texas' urban areas, and are used on golf courses, parks, highway medians and landscapes. A 1986 survey in BioCycle magazine stated that more than 200 urban areas nationally compost sludges.

Many groups benefit when sludges are reused. For municipalities, sludge application programs can be less expensive than landfills or land disposal sites. For farmers and others who want an economical fertilizer, sludges contain significant amounts of nitrogen, phosphorous and other nutrients. If managed properly, sludge application is environmentally sound and is not likely to contaminate ground or surface water.

There can be problems associated with carelessly applying sludges. Odor and fly problems were of such concern northwest of Houston that residents protested and enacted ordinances banning sludge application. Potential environmental hazards include build-up of heavy metals and organic chemicals which may be taken up by crops and may run off into surface waters, and nitrates that may be leached into groundwater supplies. Small numbers of fecal bacteria and viruses may also survive wastewater treatment processes.

Despite the risks, no instances of ground or surface water contamination or disease outbreaks have been reported in the U.S. as a result of sludge applications. Nitrate and heavy metal concentrations have increased in areas where sludges have been applied, although in most cases levels are still within regulatory limits.

WHAT IS SLUDGE?

Sludges are produced during wastewater treatment. Wastes first receive primary treatment where solids are removed that settle out easily. Primary sludges are 93-97% water and often need to be thickened and dewatered before application. Trickling filters, activated sludge processes and attached growth systems are used in secondary treatment. These sludges have a solids content of only 0.5-2%. In the future, many treatment plants will be producing sludges using tertiary treatment such as chemical precipitation and filtration, in which lime and polymers are used to thicken and dewater sludges.

Sludges are "stable" when odors, insects and pathogens are controlled. Sludges can be stabilized by aerobic digestion (uses oxygen) or anaerobic digestion (uses no oxygen), which lessen pathogen and odor problems by reducing volatile organics. Lime stabilization kills pathogens in two hours and immobilizes heavy metals when high pH levels are maintained. Oxyozonation is a chemical stabilization process that uses pressurized oxygen and ozone under acidic conditions. It is simple, economical, and requires less space than biological processes (Carlile, 1986).

Treatment methods and chemical characteristics influence how sludges can be used. Only sludges that are not harmful and pass Resource Conservation and Recovery Act toxicity tests may be land applied.

In most cases, industrial sludges with high heavy metal contents are not being land applied in Texas. Sludges from the brewery and food processing industries are teeing used to produce composts on a limited basis. In Gladewater, sludges from a brewery and local wastewater treatment plants are mixed with sawdust to produce composted potting soils.

EPA requires that sludges must be stabilized to reduce odors before being applied. Pathogens must be reduced by one of EPA's Processes to Significantly Reduce Pathogens (PSRP) such as aerobic digestion, air drying, anaerobic digestion, composting and lime stabilization.

Following application of PSRP sludges, grazing by animals whose milk or meat will be consumed must be prevented for at least one month and public access must be controlled for at least a year. PSRP treatment is acceptable if the sludge will not contact the edible portion of the crop.

EPA also specifies stricter treatment methods termed Processes to Further Reduce Pathogens (PFRP), which include drying sludge to a cake form with a moisture content of less than 10%, wind-row composting, heating liquid sludge and pasteurization. Sludges must be treated to PFRP levels if crops are grown for direct human consumption within 18 months of application.

SLUDGE REGULATION

Agencies regulating sludge usage include EPA, TDH, the Texas Water Commission (TWC), the Texas Water Development Board (TWDB), the Texas Air Control Board (TACB), and the Texas Railroad Commission (TRC).

EPA establishes treatment procedures and guidelines for sludge application, and develops regulations that dictate the amount of heavy metals that can be added to soils in application projects. For example, EPA requires that annual cadmium applications can not contain more than 0.45 pounds per acre, and cumulative loadings cannot exceed 18 pounds per acre.

EPA is developing guidelines for sludge management programs (40 CFR 501) which may require states to compile information on: 1) where sludges are generated and land applied, 2) sludge quality, and 3) the effects of application on water quality, soils, crops and human health. EPA is also developing technical recommendations and best management practices (40 CFR 503) that will protect public health and the environment, and risk assessments and profiles of pollutants and pathogens that may be present in sludges. EPA may require increased monitoring for many application sites, including those where sludges are applied to croplands.

EPA also has funding available for sludge research projects and works with TWDB in sponsoring "innovative and alternative" (I&A) sludge management projects.

In Texas, regulatory authority for sludge management is mainly divided between TDH and TWC. TDH regulates land application programs run by private sludge management companies. TWC regulates compost production and programs that apply sludge at wastewater treatment plant sites or land owned or leased by cities.

Some significant TDH regulations are: 1) 8 dry tons of sludge can be applied per acre per year, but exceptions can be granted for increased amounts; 2) lead concentrations in sludges used for food-chain crops cannot exceed 1,000 parts per million and cumulative loadings can not exceed 700 pounds per acre; 3) sludge application sites must be at least 500 feet from public water wells, 200 feet from lakes and rivers, 300 feet from residences, and 1,000 feet from schools and residential or business developments; 4) soil pH levels must be more than 6.5 when sludges are applied; and 5) sludges applied to unvegetated lands or soils with slopes greater than 9% must be incorporated within 48 hours of application.

Significantly, TDH requires that sludges only need to be tested twice annually at the wastewater treatment plant. Surface and ground water monitoring is not required unless problems are suspected.

Data on Texas cities that land apply sludge are lacking. Dallas and Fort Worth have experimented with growing crops on dedicated sludge disposal sites, and Palestine, Harlingen and Brownsville are growing grasses and cover crops with sludges. In most cases, these crops are discarded or used for animal feed.

AGRICULTURAL PRODUCTION

Most of the sludges that are land applied in Texas are used in agricultural production. Management companies bid to haul and dispose of sludges for utility districts, who pay the firms to operate the programs. The sludges are usually given to farmers at no charge. Many sludge management firms advise producers on application rates, cropping patterns and soil and sludge characteristics.

The method of application depends on whether the sludge is in a liquid or cake form. Liquid sludges can be subsurface injected or spray irrigated (spraying may carry pathogens relatively long distances and may allow sludges to stick to some plant leaves). Solid sludges can be applied with a manure spreader and incorporated into the soil.

Sludges are often applied during fallow periods. In a program near Houston, sludges are applied to pastures throughout the growing season. While cattle graze in one area, other sections of the pasture receive sludge. Grazing areas are rotated following a 30-day waiting period.

Sludges are commonly used for production of grasses and forage crops including wheat, sorghum, hay, and corn, although cotton, rice and peanuts have also been grown.

During wet weather, immediate sludge application may be impractical and temporary above- ground storage may be necessary. Last year, a study investigated surface storage, using plastic liners to prevent seepage and berms to reduce run-off (Hornby, 1987a). There was no evidence of heavy metals leaching to lower soil profiles and concentrations of heavy metals beneath sludge storage areas did not damage the environment.

Sludges are a valuable resource (Table 1) providing nitrogen, phosphorous and potassium and improving soils. However, cost savings vary as differing amounts are applied to meet specific soil and crop needs.

Sludge applications should be based on agronomic rates: the amount of nitrogen and phosphorous applied should equal the needs of the crop. Determining the amount of sludge needed to supply a given amount of nitrogen is complicated because liquid and cake sludges contain differing amounts. Liquid sludges contain 50-60% plant available nitrogen (PAN), while dried sludges contain only 25-30% PAN. Sludges gradually release nitrogen and there are indications that this slow release closely parallels crop needs (Figure 2). Because some nitrogen remains in soils after sludge applications, soil tests should be performed before each growing season. By matching sludge applications to soil and crop needs, nitrate contamination of groundwaters can be avoided.

Heavy metal concentrations will determine when sludges can no longer be safely applied. Sites can generally not be used for additional applications when cumulative loadings reach EPA limits. Heavy metals are relatively immobile and remain in soils long after sludge applications have ceased.

TEXAS EXPERIENCES

Yield increases and fertilizer savings have been reported in many areas of Texas where sludges have been applied. Houston and Austin supply sludges to nearby farmers, and San Antonio, Fort Worth and El Paso are considering similar ventures.

Houston uses private firms to land apply 44% of its sludges, most of which are used to grow pastures in Brazoria and Fort Bend counties. In the second half of 1986, 13,490 dry tons were land applied. Many of the smaller utility districts around Houston also operate sludge application programs. In Brookshire, sludge cake is applied to bermudagrass, hay and corn with reported fertilizer savings of $50-60 per acre. Liquid sludges sprayed on hay crops produced two additional cuttings per season.

One of the more interesting sludge application programs in the Houston area is one that never got off the ground. Last year a sludge management firm proposed shipping a bargeload of 52,000 tons of Philadelphia's sludge to Texas for land application. If the deal had gone through, it could have supplied 10,000 acres of Texas farmland with sludges providing $200,000 worth of fertilizer.

Austin uses a private firm to manage its sludge application program. In 1986, the city began to excavate 40,000-50,000 dry tons of sludges from lagoons which had received sludges for 30 years. Sludges are provided to area farmers at no cost and the city grows crops on-site.

Many research projects being conducted in Texas show that using sludge saves money and is environmentally sound.

A project sponsored by the Texas Agricultural Extension Service in Williamson County compared yields and costs of growing cotton crops which received sludges and fertilizers. Yields were similar, but sludge use resulted in a savings of $20 per acre because less fertilizer was required. Other research suggests that sludges may inhibit cotton root rot.

Fort Worth sponsored a study (Hornby, 1987b) using liquid sludges to fertilize bermudagrass and wheat crops. Sludge applications increased yields in both crops and promoted shoot production in wheat. Wheat grown with 6.8 tons of sludge per acre yielded 4,677 pounds, while wheat grown with fertilizers produced 2,054 pounds. Similar amounts of sludges increased Johnsongrass yields from 1,446 to 4,851 pounds per acre.

A project at Sam Houston State University (Lane, 1984) studied the effect of dried sludges on bermudagrass growth. Yields improved as increasing amounts of sludge were applied (sludges providing 245 pounds of nitrogen improved yields by 400%).

The impact of sludge application on surface and groundwater quality was also studied on a ranch in Austin County (Hornby, 1986). Soils and water supplies were monitored before, during and after sludge applications. Soils showed increased concentrations of all heavy metals except nickel and mercury following applications. Houston-area sludges could be applied to this soil for four years before EPA cumulative limits for cadmium were reached. Only one groundwater well contained nitrates and that was below EPA drinking water standards.

In another project, alfalfa and bermudagrass were grown with Houston area industrial sludges that could potentially cause mutations (Fiedler and Brown, 1987). Early findings suggest that the crops did not take up the hazardous compounds.

A computer program developed by the Ohio Agricultural Experiment Station (Watson, 1985) recommends sludge application rates based on crops, soil conditions, sludge characteristics, crop yield goals and cumulative sludge loadings.

A CASE THAT FAILED

Although the prospects for sludge application are bright in many areas of Texas, Austin and Waller counties enacted ordinances intended to ban sludge applications.

In 1984, citizens began complaining that Houston sludges being applied to farms near

Sealy and Bellville were responsible for foul odors, swarms of biting flies, increased buck traffic and sludge spills. There were concerns that the sludges had not been properly digested and lime stabilized and were polluting creeks and groundwater supplies. TWC investigated and found no objectionable odors or water pollution. TACB fined two sludge management companies $15,000 because of odor problems.

The ordinances require that each load of sludge be tested at the landowner's or contractor's expense and prohibit the application of sludges that contain or may generate odors, pathogens, heavy metals or organic chemicals. The ordinances have not been tested in court and are not being enforced by TDH, which continues registering new sludge application sites in the area.

Composts produced by mixing sludges and bulking agents (wood chips, sawdust, water hyacinths and solid wastes) condition and fertilize soils. Because of the high potential for human contact, most composted sludges must be treated to PFRP levels and have a moisture content of less than 10%. Producing compost is attractive for cities that generate sludges with low levels of heavy metals, and areas without nearby farmland available for sludge application programs. Many cities sell compost, offsetting production costs.

Special care needs to be taken when composted sludge is sold to the general public. Recommendations should accompany the compost, indicating that it may be OK to use on landscapes, but warning that it may not be appropriate for root crops or crops that will be eaten raw.

The most common method of composting sludges in Texas is the wind-row process, which involves mixing dewatered sludge with a bulking agent. The compost is formed into long, open-air piles which are turned frequently to aerate and expose the compost to temperatures capable of killing pathogens and parasites.

Houston flash dries 54% of its sludges to produce a soil amendment ("HouActinite") that is sold to citrus producers in the Rio Grande Valley and Florida and is applied to farms in the Houston area.

Austin mixes thickened sludge with dried water hyacinths (used in its wastewater treatment process) to produce a wind-row compost which is made available to city departments and the general public.

Fort Worth produces roughly 405,000 wet tons of sludges annually which are anaerobically digested and air-dried for up to six months. The sludge has been given to the Texas Highway Department for the past 10 years for use in landscaping highway medians and right-of-ways.

For more than 30 years, El Paso has reused almost half its sludges to produce anaerobically digested sludge composts, which are sold for $5.25 per cubic yard.

Dallas recently sponsored a project to examine the feasibility of composting its sludges

(Carmichael, 1987). A compost was produced by mixing thickened sludges with tree trimmings and straw that was grown on a sludge disposal site. The study recommended bulking agents, sizing and wind-row design that could be used in a full-scale facility. The compost would be low enough in heavy metals for uncontrolled uses, and little odor was expected.

The Trinity River Authority is investigating composting 10 dry tons of sludge per day at its Grand Prairie wastewater treatment plant.

USE IN FORESTS AND MINED LANDS

Sludge applications to forests and mined lands have been successful in other states, but are not widely practiced in Texas. More than 176,000 acres of Texas forests were replanted in 1985 and sludge could be used on much of that land. TRC data indicate that 3,600 acres of lignite were mined in Texas in 1986 and that land will have to be reclaimed.

Sludges contain nutrients that are often lacking in both forest and disturbed mined soils, improve yields, promote the rapid growth of grass and vegetative cover, and increase soil water- holding capacity. Difficulties encountered with these projects include limiting public access and preventing contamination of surface and groundwater supplies. Established forests, newly planted stands and recently cleared land are suitable for sludge application. Southern pines and hardwoods have an average nitrogen uptake of 225-300 pounds per year. Seattle applies dewatered and digested sludges to 2,300 acres of forests, and its research has shown that sludges increased tree growth by 50400%.

There is only one instance in Texas where sludges were applied to revegetate mined lands: the U.S. Forest Service (USFS) applied sludges in 1983 and 1986 to reclaim a gravel pit near Cleveland. USFS officials say the project was a success, but was stopped by public opposition.

Many research projects at Texas A&M University have investigated sludge usage in reclaiming mined lands. Sludges were used to grow bermudagrass on mined soils in Grimes County (Hornby, 1985). Single sludge applications provided more PAN than four years of commercial fertilizers, increased soil nitrogen (which was slowly released during the year) and improved the soil's moisture holding capacity by 1100%. In a study comparing sludge and fertilizer, sludges increased bermudagrass yields, infiltration (by 38%) and plant available water (Cocke, 1986).

The economics of using sludge composts to reclaim mined lands in the Bryan-College Station area were evaluated (McDow, 1986). The study indicated that using a wind-row compost consisting of municipal sludges and solid wastes to reclaim mined lands would cost area utilities 40% less than landfilling, even if the sludge was given away. Composting was predicted to become more economical than landfilling as regulations for monitoring increased and landfills had to be constructed.

In much of Texas, sludges are being viewed as a resource instead of a liability. Cities are looking at reusing sludges and sludge composts rather than emphasizing sludge disposal. The results are heartening. Farmers have reported increased yields and fertilizer savings from using sludges. No instances of surface or ground water contamination have been cited as a result of sludge use.

It must be noted that improper management of sludge application projects can lead to problems involving pathogens, heavy metals, flies and odors. However, when compared with possible environmental costs associated with other forms of disposal, sludge application remains as an attractive alternative in most cases.

Information is needed on the characteristics of sludges generated at wastewater treatment plants. There is a lack of data describing the quality of sludge being used in land application projects. Educational programs are needed to train regulatory personnel and sludge management professionals in proper sludge application techniques to more precisely match application rates to crop needs. Development of safe sludge application technologies will be needed to create benefits from the use of sludges as a renewable resource.

REFERENCES

Carlile, Bobby L., Developing a Sludge Utilization Program: Chemical vs. Biological Stabilization and Pathogen Reduction Systems, Texas A&M University, College Station, TX, 1986.

Carmichael, Richard and Michael Collins, Small Scale Pilot Composting Study, Southern Methodist University, Dallas, TX, 1987.

Cocke, C.L., and Kirk Brown, The Effect of Sewage Sludge on the Physical Properties of Lignite Overburden, Texas A&M University, College Station, TX, 1986.

Fiedler, D.A., Kirk Brown and K.C. Donnelly, Mutagenicity of Plants Fertilized With Mutagenic Municipal Sewage Sludge, Texas A&M University, College Station, TX, 1987.

Hornby, William, Kirk Brown and J.C. Thomas, Nitrogen Mineralization of Revegetated Lignite Overburden in the Texas Gulf Coast, Texas A&M University, College Station, TX, 1985.

Hornby, William, An Assessment of the Environmental Impact of Land Application of Houston Wastewater Sludge at the Mossy Oaks Ranch in Austin Co., TX Kirk Brown & Associates, College Station, TX, 1986.

Hornby, William, The Beneficial Use of Village Creek Wastewater Treatment Plant Sludge for Agricultural Crops: A Field Plot Demonstration, Kirk Brown & Associates, College Station, TX, 1987b.

Hornby, William, Impact of Temporary Wet Weather Storage of Houston Wastewater Sludge on Soil and Soil Leachate Quality, Kirk Brown & Associates, College Station, TX, 1987a.

Jones, S.G., Kirk Brown, L.E. Deuel, and K.C. Donnelly, Influence of Simulated Rainfall on the Retention of Sludge Heavy Metals by the Leaves of Forage Crops, Texas A&M University, College Station, TX, 1978.

Lane, Robert A., The Effect of Sewage Sludge Application to Bermudagrass on Forage Quality, Production, and Metal Accumulation, Sam Houston State University, Huntsville, TX, 1984.

Mc Dow, Ed, Co-Composting: An Alternative Solid Waste Management System (Feasibility Study), Riewe and Wischmeyer, College Station, TX, 1985.

Watson, Maurice, "Sewage Sludge Computer Program", Fertilizer

Progress, Washington, DC, May-June, 1985.

Carlile, Bobby L., "Fertilizer Value of Municipal Sludge," Soil Profiles, Vol. 1, No. 1, Texas A&M University, College Station, TX, 1983.

Environmental Regulations and Technology: Use and Disposal of Municipal Wastewater Sludge, EPA, Washington, DC, 1984.

Process Design Manual: Land Application of Municipal Sludge, EPA, Cincinnati, OH, 1983.

Sludge: Two Decades of Progress, Municipality of Metropolitan Seattle, Seattle, WA, 1986.

Sweeten, John, Microbiological Research Summary Regarding Pathogen Survival in Sewage Effluent and Sludge, Texas Agricultural Extension Service, Texas A&M University, College Station, TX, 1982.

Texas Department of Health, Municipal Solid Waste Management Regulations, Austin, TX, 1986.

Texas Water Commission, Design Criteria for Sewerage Systems, Austin, TX, 1987.