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Agricultural Disposal Method of Construction Site Gypsum Wallboard Waste

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Over two million tons of gypsum wallboard waste is created each year. Traditionally this material ends up in landfills. The wallboard waste takes up considerable amounts of space since it is difficult to compact. Also the potentials exist for elements in the wallboard to be acted upon by bacteria in municipal solid waste and create harmful concentrations of hydrogen sulfide that can escape from the landfill. Additionally, disposal costs at both municipal sanitary landfills and construction and demolition landfills are very high exceeding $300.00 per ton in some areas. This paper explores an alternative to landfill disposal. The reuse of the gypsum wallboard scrap in agricultural uses may be a suitable best method to be used for the disposal of these materials. The paper presents the results of an experiment that investigates the agricultural use of scrap gypsum and it's effect on soybeans.

Key Words: Gypsum Wallboard, Drywall, Recycling, Tipping Fees, Disposal, Agricultural Uses

Introduction

In 1993 over 22.5 billion square feet of gypsum wallboard was manufactured in the United States. Of that amount about 10% ends up as scrap. This amounts to an addition of over 2.1 million tons of material that enters the waste stream of our society. Currently, most of this material ends up in municipal sanitary landfills or construction and demolition landfills, costing construction firms millions of dollars in disposal fees. Other options exist. These currently include reusing the waste material in the construction of new wallboard, dumping at sea, incineration, and agricultural uses. Each of these alternative disposal methods can reduce the cost of disposal and reduce the burden on municipal sanitary landfills.

Currently, contractors in British Columbia must return drywall scrap to be recycled into new wallboard. Recently, legislation requiring some form of recycling of gypsum wallboard products has been proposed in several states. In Oregon, proposed legislation would have required that all waste wallboard be recycled into new materials. Other proposed legislation in Texas would have required that all materials must be returned to a recycling facility if one exists within a radius of fifty miles. Neither of these bills passed, but this does not prohibit future legislation in these and other states.

Chemical Composition

Gypsum has been used for agricultural purposes for nearly 250 years. Its use began in Europe in the mid 18th century and was possibly introduced into the United States by German farmers. Benjamin Franklin, after returning from France in 1785, applied gypsum to a field in a pattern that read "This land has been plastered". This message was clearly visible from the pattern of enhanced growth of the clover in the soil where the gypsum was applied. Since wallboard is chemically the same as gypsum the only difference between the two is the paper cover on the wallboard. It should be an economical replacement for agricultural gypsum. (This is true for most products. Some wallboard has additives introduced into the manufacturing to increase the moisture and fire resistance of the products. These materials may not be suitable for agricultural use.)

During the manufacturing of the wallboard the gypsum, hydrous calcium sulfate (CaSO, o 2H,O is strip mined, cleaned of impurities such as shale and limestone, and crushed into small particles. These particles are then heated to remove water chemically trapped in the gypsum to alter the gypsum chemically to become anhydrous calcium sulfate (CaSO, '/21-120), commonly know as plaster of Paris. Water is the reintroduced to create a slurry (some manufacturers also introduce waste newspaper and cornstarch) that is molded between paper. The water chemically bonds to the anhydrous calcium sulfate to form crystals of hydrous calcium sulfate. The crystals of gypsum bond to each other and to the paper to from the sheets of wallboard.

Material Safety Data Sheets from various manufactures of wallboard indicate that wallboard does not contain any materials that possess a health hazard. To confirm this, a local laboratory performed a chemical analysis of four samples of wallboard (table 1). The results of the tests confirmed that no heavy metals or toxins existed in the samples that could create an adverse effect on the environment. The tests did indicate the presence of boron that can, in some soils, reach levels that can hinder plant growth. This does not affect most soils, but testing of the soils prior to application is recommended.

Table 1

Chemical Composition of Ground Gypsum Wallboard

Chemical Characterized	Quantity (%)	Chemical Characterized	Quantity (ppm)
Dry Matter	96.19	Sodium	161.2
Ash	82.89	Manganese	114.4
Nitrogen	0.15	Phosphorus	85.5
Sulfur	17.6	Boron	48.1
Calcium	23.	Zinc	40.2
Magnesium	7.4	Chromium	21.7
Potassium	0.1	Copper	10.3
		Lead	3.6
		Mercury	1.2

* Values are mean of four replicate samples of gypsum wallboard.

Soil amendment uses

The application of gypsum provides nutrients for plant growth, increases the infiltration of water into soil, can reduce salt concentrations in soils, and can improve the physical properties of clay soils. The calcium and sulfur in the gypsum are essential for plant growth. The application of these elements is beneficial to many crops including peanuts, alfalfa, and clover. Ironically, since the introduction of the Clean Air Act in 1970, concentrations of sulfur in soils have diminished and the need for fertilizers containing sulfur is increasing. Water collects in basins that naturally occur in some areas of the coastal plains of the eastern United States. The application of gypsum to these soils can increase the infiltration rate of water into the soil improving the soil for agricultural uses. When applied to soils contaminated by road salts or soils in western states that have high salt concentrations the gypsum reduces the sodium concentrations in the soil. Gypsum also adds needed calcium to acid soils increasing their productivity. Gypsum when introduced into clayey soils improves its structure and tilth, allowing it to be broken up into smaller pieces again improving the agricultural potential of the soils.

Materials and Methods

This study used residential drywall scrap run once through a "Gypchipper" commercial chipper. This process was extremely slow and dusty. The "Gypchipper" could only accept one piece at a time with a maximum width of 24 inches. The average particle size of materials produced by running one pass through the "Gypchipper" is given in Table 2. The ground material was applied at three rates, 0, 5.38 and 10.75 metric tons/hectare (0, 14.7 and 29.4 tons/acre). Each treatment was replicated four times in a randomized complete block design on a Fitchville silt loam soil (Fine-silty, mixed, mesic Aeric Ochraqualf). The material was surface applied over cornstalk residue from the previous crop in plots 3 by 10 meters, and 'Bicolor' sweetcorn was no till planted on May 16, 1995. Because of wet, cold soil conditions the stand was unsatisfactory and the plots were rototilled on June 9, 1995, to kill the corn seedlings, incorporate the gypsum 7.5 to 10 cm (3-4 inches deep) and prepare for seeding of 'Edison' soybeans in 75-cm (30-inch) rows. The soybeans were growing nicely when the plots were sprayed with Sencor herbicide. For some reason this normally safe herbicide caused 80% of the plants to die within two weeks. Edison soybeans were replanted on June 26 again in 75-cm (30-inch) rows. Weed control was excellent and no further Sencor injury was noted. The plots were hand harvested on October 19, 1995. Two row segments 10 meters long were harvested from the interior of each four-row plot. Plants were tied in bundles, transported to the Ohio Agricultural Research and Development Center (OARDC) and run through a small plot combine. Grain moisture, bushel weight and yields were measured. Yields were low because of late planting, wet conditions early and inadequate moisture late in the growing season.

The upper trifoliate leaves were collected in August at early flowering for determination of Ca and Mg in the tissue by dry ashing, HCI extraction of the ash and determining the Ca and Mg by atomic absorption spectroscopy. Soil samples were collected from the 0-20-cm (0-8-in) depth on October 2, 1995 and taken to the Research Extension Analytical Laboratory (REAL) at the OARDC Wooster, Ohio where they were analyzed by Recommended Chemical Soil Test Procedures for the North Central Region. Ground samples of drywall were analyzed by the

REAL Lab to characterize its chemical composition. The average composition is reported in Table 2. The impact of the ground drywall on soil tilth was assessed by doing soil cone penetrometer readings in the plots the following spring (4-18-96). At least 10 probes were performed per plot down to a depth of 12 inches in hills created by chisel plowing with a "Dickey John" soil penetrometer. The maximum pressure noted in each 12 inch deep probe was noted in p.s.i. units. The data were statistically analyzed using ANOVA and calculating the linear regression between the soil and plant factors and the application rate of the drywall (graded variable).

Table 2

Particle Size Distribution of Pulverized Waste Drywall

Size Range	Sample Mean (%)	Sample Std. Dev. (%)	Coeff. Of Variation (%)
Paper & Particles	7.8	5.4	69
> 6 Mesh	41.5	3	7
6-8 Mesh	7.8	1.3	17
8-35 Mesh	16	2.2	14
35-60 Mesh	16.3	4.6	28
< 60 Mesh	10	4.6	46

* Means and associated statistics from sieving four samples of drywall after one pass through the Gypchipper.

Results

The principal results are presented in Table 3. Items are reported as the sample mean +/-sample standard deviation. The level of significance by linear regression is given as the probability of "F" for regression in the last column of Table 3. The drywall itself was quite high in calcium, magnesium and sulfur (Table 2). There were a number of trace elements present in the drywall, but only boron at 48 ppm looked high enough to be of any potential concern. Each ton of drywall applied would be applying 0.096 lbs. of boron. At rates of 75 or more tons/acre the level could build up and damage B sensitive crops. That did not happen in this study. Note grain yield and test weight were not significantly related to the rate of drywall applied although there was a slight positive trend for both. The soil exchangeable Ca and % Ca on the soil cation exchange capacity was significantly and positively correlated to the rate of drywall applied at the P(<0.05) level. Magnesium levels were not greatly reduced on the soil CEC or in the soybean plant tissue (Table 3). There was a modest but significant (P<0.0 1) decrease in soil penetrometer resistance readings with increasing rates of ground drywall applied when measured on the plots the following Spring, from 187 for the check plots to 171 lbs/in' for the 10.7 metric tons/ha plots. The backing paper from the shredded drywall was observed to be completely decomposed by April 1996, 11 months after application of the material in 1995.

Table 3

Effect of Drywall on Soybeans and Soil Test Results

*Rate of Drywall (Metric tons/ha)**				
0	5.37	10.7		
Grain Yield(Bu/a)	13.5 ± 2.0	14.5 ± 3.0	14.0 ± 3.6	0.807
Grain Test wt.(Lbs/Bu)	54.2 ± 37	54.3 ± 1.1	54.9 ± .37	0.269
Leaf Ca (%)	0.716 ± .12	0.739 ± .11	0.559 ± .05	0.066
Leaf Mg	0.225 ± .03	0.237 ± .02	0.230 ± .06	0.886
Soil pH	6.6 ± 0.3	6.7 ± .02	6.4 ± .03	0.332
Soil Bray P (ppm)	52 ± 10	62 ± 6	54 ± 17	0.822
Soil Exch. Ca (ppm)	1360 ± 182	1474 ± 152	1619 ± 189	0.026
Soil Exch. Mg (ppm)	310 ± 39	302 ± 14	283 ± 44	0.659
Soil CEC (meq/100g)	10 ± 0.8	10.3 ± 1	11.3 ± 1	0.074
Soil Ca Saturation CEC (%)	68 ± 1	70 ± 2	73 ± 4	0.029
Soil Penetrometer Readings (lbs/in2)	187 ± 23	180 ± 27	171 ± 31	0.004

*Numbers presented are sample means ± sample std. deviations.
**Describes plant measurement data or soil test data fit to rate of drywall by linear regression.

Construction Recycling Resources

AIA Environmental Resource Guide, 1735 New York Avenue, NW, Washington, DC 20006. 800-365-2724.

A Resource Guide to Recycled Construction Products and Energy Efficiency, California Integrated Waste Management Board, 8800 Cal Center Drive, Sacramento, Ca. 95826. 916-255-2385.

A Guide to Recycled Products, Building and Construction Products. Solid Waste Department, Metro. 600 NE Grand Ave., Portland, Oregon. 97232, 503-797-1650.

Construction Site Recycling and Recycled Product Guidebook, Minnesota Office of Waste Management. 612-2963417.

Construction Site Recycling: A Handbook on Recycling Building Materials for Home Builders, Developers, and Contractors, National Association of Home Builders, 1201 15' Street NW, Washington, DC 2005. 800368-5242 ext. 485.

Resource Conservation Research House Information Guide, and *Builders Guide to Residential Construction Waste Management,* National Association of Home Builders Research Center, 400 Prince George's Boulevard, Upper Marlboro, Md. 20772-8731. 301-249-4000.