

Using recycled wallboard for crop production

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Gypsum wallboard is commonly used to cover the interior walls of homes, offices and other structures. It is composed of gypsum (calcium sulfate dihydrate) and a paper backing that makes up approximately 2–4% of the total wallboard weight.

It is estimated that nearly 30 billion square feet of gypsum wallboard are manufactured each year in North America.¹ The rule-of-thumb suggested by waste management specialists is that approximately one pound of waste is created for every square foot of construction area, which translates into about one ton of scrap per home resulting from end cuts, cut outs and broken boards (figure 1).

Much of this material is not reusable and is usually deposited in a landfill. A study conducted in Wisconsin estimated that construction of a typical single family home in 1992 encumbered waste disposal expenses of over \$700.² The study estimated that between 77,000 and 102,000 cubic yards of construction waste was generated in Dane County alone, at a disposal cost of between \$1,000,000 and \$1,450,000. Wallboard was estimated to make up 15% of the waste by volume.

A win-win solution?

Recently, there has been increasing interest in recycling gypsum wallboard by crushing and sieving scrap material and applying it to crops or on-site at the construction location. Land application of this material could offer a win-win solution for both the creators and the users of this construction debris because of reduced disposal costs and potential agronomic benefits.



Figure 1. Scrap wallboard collected from home and commercial construction sites.

Gypsum is used in agriculture as a fertilizer and as a soil amendment. Both calcium and sulfur are essential plant nutrients. Normal agronomic application rates for calcium would be in the range of 100 to 200 pounds of calcium per acre. Sulfur would be applied at 25 to 50 pounds of sulfur per acre. It is likely that

¹ Gypsum Association, <http://gypsum.org>.

² Walther, R., and J. Udell, The quantity and costs of managing single-family home construction wastes in Dane County, Wisconsin.

Table 1. Chemical analysis of crushed gypsum wallboard.

Plant nutrients (ppm)												
TKN	P	K	Ca	Mg	S	Zn	B	Mn	Fe	Cu	Al	Cl
280	<22†	<62	160,360	8,475	133,821	11.5	42.5	44.5	858	7.1	295	194
Trace elements (ppm)												
		Cd	Cr	Co	Mo	Ni	Li	As	Pb	Se		
		3.1	11.6	9.2	2.7	20.1	<2.5	<28	15.6	<19		

† < indicates below detection limit.

the rate of crushed wallboard would be higher because of the spreading characteristics of the crushed material.

The need for these nutrients depends on the crop, the soil type, the existing soil supply, and the contribution from other sources. Gypsum is not a liming material and will not increase soil pH. In fact, large applications of gypsum may lower the soil pH slightly because the calcium ions displace hydrogen ions from clay surfaces, increasing the concentration of hydrogen ions in the soil solution. This effect is relatively short-lived and does not affect crop growth. An analysis of crushed gypsum wallboard is shown in table 1. The values for calcium and sulfur are slightly below those reported for commercial gypsum fertilizer.

Nutrient needs of plants

Calcium

Plants require calcium for proper cell division and for the normal function of cellular membranes. Most agricultural soils have adequate calcium because it is commonly found in soil minerals and tightly held on the surfaces of clay particles as Ca^{++} —the form in which it is available in plants.

In addition, most agricultural soils are routinely limed with several tons per acre of calcium carbonate or similar materials to increase the soil

pH. Potatoes and peanuts are two crops that respond to calcium fertilization. This is because they are grown on acid soils and the crop is underground where it does not receive much calcium from the plant.

A study conducted in Wisconsin showed potato yield and quality increased when gypsum fertilizer was applied to provide 225 pounds of calcium (approximately 1000 pounds of gypsum) per acre.³ It was also found that the concentration of calcium in the potato peel increased, improving the tuber's resistance to decay from bacterial soft rot in storage.⁴ Many potato growers routinely apply gypsum or other calcium sources as part of their fertility program.

Sulfur

Plants need sulfur to create specific amino acids. Sulfur is also a component of certain plant vitamins and enzymes. Sulfur for plants exists in the soil as the sulfate (SO_4^-) anion. It can be lost when it leaches because it is not held on clay surfaces. Sulfur is also closely associated with soil organic matter and is reduced in the soil because it is included in the microbial and plant residues.

Field crops have different sulfur needs. Alfalfa has a high need, while corn and small grains need less. Response to sulfur is affected by management practices such as the use of manure. Standard dairy manure contains about

³ Simmons, K.E., K.A. Kelling, R.P. Wolkowski, and A. Kelman, Effect of calcium source and application method on potato yield and cation.

⁴ Tzeng, K.C., A. Kelman, K.E. Simmons, and K.A. Kelling Relationship of calcium nutrition to internal brown spot of potato tubers and subapical necrosis of sprouts.

1 pound of sulfur per ton or 2.5 pounds of sulfur per 1000 gallons.⁵ Normal manure applications can supply all the sulfur that a crop needs.

Sulfur is also added to soils by atmospheric deposition in rain and snow. The amount of sulfur supplied this way is related to the proximity to industrial facilities. Southern Wisconsin counties are credited with 20 pounds of sulfur per year in precipitation and northern counties are credited with 10 pounds of sulfur per year. Recent surveys are showing lower amounts of sulfur in precipitation presumably because of the effectiveness of clean air laws that have reduced industrial emissions.

Other nutrient benefits

There are also small amounts of other plant nutrients in wallboard that would be beneficial. Alfalfa has a relatively high requirement for the micronutrient boron. A 10-ton/acre application of crushed wallboard will supply about 25% of the annual agronomic need of alfalfa. There is also a significant amount of magnesium in this material. The loading of heavy metals that are regulated by the EPA in materials such as municipal biosolids is very low.

Gypsum is also recognized as a soil conditioner and is commonly used on arid soils to improve soil structure. Medium- and fine-textured soils form structural aggregates by chemical bonding between individual soil particles. Soils in arid regions tend to be high in sodium because salts accumulate due to limited rainfall. High sodium levels disperse soil particles, thereby degrading structure, increasing bulk density, and reducing porosity, gas exchange and water infiltration.

Calcium encourages flocculation and formation of soil structure. Most soils in arid regions have high pH levels; therefore, a material such as gypsum rather than lime is used to supply calcium (displacing sodium) to the clay surfaces. This response is not common in the more humid regions of the U.S., although there

may be situations where soil structure degrades from high sodium-containing materials such as cheese plant waste or when in close proximity to areas treated with sodium-containing de-icing salt.

Potential concerns

A potential concern with applying crushed wallboard is wind drift, because the material is pulverized into fine particles. The particles dissolve more quickly, but are more difficult to apply uniformly.

In one study, a wallboard that was crushed by a hammer mill was very finely divided.⁶ A sieve test of the material showed that 71%, 61%, 40%, and 24% passed through 8-, 20-, 60-, and 100-mesh sieves, respectively. Mild breezes significantly affected the distribution of these fine materials when hand-applied as shown in figure 2.

Spreading uniformity would likely be an issue with a standard spinner lime spreader. Most dry fertilizer materials come as pellets, so they can be spread in spinner-type applicators. Different pelletized fertilizers are commonly blended so that application can be handled in a single pass. It would not be reasonable to blend crushed wallboard with pelletized fertilizer because the different sizes segregate,



Figure 2. Hand applying crushed wallboard to research plots. Note wind drift.

⁵ Kelling, K.A., L.G. Bundy, S.M. Combs, and J.B. Peters, Soil test recommendations for field, vegetable, and fruit crops.

⁶ Wolkowski, R.P. 2000, Land application of crushed gypsum wallboard waste for alfalfa.

Table 2. Effect of crushed wallboard and gypsum fertilizer on the yield of potato at three Wisconsin locations (values are the average of 2 years at each site).

Material- treatment rate (lb Ca/acre)	Site		
	Antigo	Hancock	Rhineland
	cwt/acre		
Control	539	369	445
Wallboard - 100	535	381	416
Wallboard - 500	533	380	418
Gypsum fert. - 100	543	380	420
Gypsum fert. - 500	520	379	412



Figure 3. Small plot study following treatment with crushed wallboard.



Figure 4. Small plot study in the first year of alfalfa growth.

resulting in poor nutrient distribution. Making ground wallboard into pellets eliminates these problems and enhances its use as a fertilizer, although it adds some expense to the recycling effort.

Field research results

Several states have conducted small plot field research to evaluate the agronomic response from land application of crushed wallboard. A one-season study in New York on very acid soil demonstrated a 25% positive yield response to crushed wallboard on corn.⁷ The same response was observed with agricultural gypsum or lime. The author attributed the response to increased availability of calcium, magnesium, and sulfur.

Several studies have evaluated land application of crushed wallboard in Wisconsin. Most of these utilized a small plot approach to simulate field-applied rates as shown in figures 3 and 4. A study on potatoes did not produce a significant (hundred-weight per acre) yield effect at any of three locations over 2 years.⁸ These data are shown in table 2 and are averaged for both years of the study.

Significant responses in tuber quality and peel calcium content were observed at the Rhineland location in both years of the study (table 3). This site had the lowest soil test calcium levels of any of the locations (342 and 225 ppm in years one and two, respectively).

⁷ Burger, M.E. 1993, Potential of pulverized construction drywall waste as a soil amendment.

⁸ Wolkowski, R.P., Turning drywall into fertilizer.

Table 3. Effect of crushed wallboard and gypsum fertilizer on the incidence of hollow heart defect, dry matter content, and peel calcium level at Rhinelander, WI.

Material- treatment (lb Ca/acrea)	Year 1			Year 2		
	Hollow heart	Dry matter	Peel calcium	Hollow heart	Dry matter	Peel calcium
	%			%		
Control	5	22.2	0.09	2	20.6	0.19
Wallboard - 100	3	22.7	0.09	0	20.8	0.22
Wallboard - 500	2	24.0	0.14	0	20.9	0.25
Gypsum fert. - 100	0	23.0	0.09	0	21.0	0.21
Gypsum fert. - 500	0	23.8	0.11	0	20.8	0.27

Table 4. Yield response of alfalfa (second hay year) to the application of crushed wallboard at four Wisconsin locations.

Treatment	Arlington	Ashland	Lancaster	Spooner
	tons/acre			
Control	4.0	2.6	4.2	3.4
50 lb S†/acre	4.0	2.7	4.0	3.6
1 ton CW‡/acre	4.1	2.7	4.2	3.7
4 ton CW/acre	3.9	2.8	4.1	3.8
16 ton CW/acre	4.1	2.8	4.1	3.9

† Applied as gypsum fertilizer. ‡CW=crushed wallboard.

Hollow heart has been suggested as an indicator of calcium deficiency; although the incidence was relatively low, the difference between the control and the treated plots was significant. Higher dry matter is favored because it improves the storability and processing quality of the tubers. The difference was significant in the first year. A significant increase in tuber peel calcium was noted in both years. As previously discussed, higher peel calcium levels correlate with greater resistance to soft rot decay in storage. No differences in performance between crushed wallboard and equivalent rates of gypsum fertilizer were observed.

An extensive study that evaluated alfalfa's response to the application of crushed wallboard was conducted over three years at four Wisconsin locations.⁹ The study compared the agronomic rate of S as gypsum fertilizer with rates of crushed wallboard ranging between 1 and 16 tons/acre. Yield data for the second hay year are shown in table 4. These data do not show a negative effect of treatment application on yield and in fact a small, but significant positive response to the wallboard application was observed at Ashland and Spooner. Both of these locations are in northwestern Wisconsin, a region where the contribution of sulfur in rainfall is low.

⁹ Wolkowski, R.P., Land application of crushed gypsum wallboard waste for alfalfa.

Table 5. Effect of the application of crushed wallboard on the stand of alfalfa and soil test 2 years after application, Spooner, WI.

Treatment	Stand	pH	Calcium	Magnesium	Sulfur
	plants/sq. ft.				
Control	9	6.6	788	118	6
50 lb S†/acre	9	6.6	800	130	5
1 ton CW‡/acre	8	6.6	875	95	9
4 ton CW/acre	8	6.6	938	58	12
16 ton CW/acre	7	6.4	1563	25	120

† Applied as gypsum fertilizer. ‡ CW=crushed wallboard.

Some of the concerns with land application of crushed wallboard relate to its effect on soil salinity and the availability of other nutrients. Large applications of available calcium will displace other positively charged ions from the clay surfaces, subjecting them to loss from the soil by leaching. Table 5 shows the effect of crushed wallboard treatments on the stand of alfalfa and the soil test two years after application. The very high rate of crushed wallboard application reduced the stand of alfalfa, although a stand of seven plants per square foot is still considered very good. As would be expected, the wallboard application increased the soil test levels of calcium and sulfur. Again it was likely that the alfalfa yield was enhanced at this site by the sulfur. The 16-ton/acre rate slightly depressed soil pH and substantially reduced the level of available magnesium.

University of Wisconsin–Extension recommendations define soil test magnesium levels below 50 ppm as deficient. Based on this research, it was recommended that crushed wallboard application be limited to 2 tons/acre on sandy soils and 5 tons/acre on medium-textured soils.¹⁰

Other opportunities to recycle crushed gypsum wallboard

Another potential opportunity for recycling by enriching the soil is by using crushed material at the construction site. Typically these sites are disturbed and may benefit from either fertility or conditioning response. This method requires the use of a portable crusher and small applicator, but would reduce the costs and logistics associated with off-site processing.

A Maryland study examined the application of wallboard or gypsum fertilizer at 5 tons/acre to established fescue.¹¹ No dry matter yield differences were observed in the year of application; however soil and tissue calcium were increased and tissue magnesium was decreased. Magnesium availability was likely decreased because of displacement by the calcium in the wallboard and subsequent leaching.

At issue in some situations is the type of wallboard that is being recycled for land application. Much of the wallboard used in commercial applications is “Type X” (fire retardant) and has about 1% fiberglass added to the gypsum mix. It was believed by some that the fiberglass could be toxic to soil organisms such as earthworms. A study was conducted in a growth

¹⁰ Ibid.

¹¹ Korcak, R., Scrap construction gypsum utilization

chamber to test this hypothesis using the protocol outlined by the USEPA, Office of Prevention, Pesticides, and Toxic Substances.¹² Rates of Type X drywall simulating application from 0.5 to 8 tons/acre were mixed with either an artificial soil or an agricultural soil collected from the field. Control treatments of nothing-added or 50-lb-sulfur-per-acre as gypsum fertilizer were included in the design. Ten earthworms were then added to the jar and their survival and weight was recorded on a weekly basis over four weeks. The earthworms lost weight in all treatments, but there were no weight difference between worms grown in soil alone or soil amended with crushed wallboard.

Will you need a permit?

A final, but very important issue that must be considered before land application of crushed wallboard is the status of the material with state and local regulatory agencies. Crushed wallboard is considered construction debris (solid waste) in many states and cannot be applied without a permit. This is the case in Wisconsin and a permit following the rules in NR 518 must be obtained before land application. Components of the permit will include the soil types at the site in question, the crops that will be grown, information from a routine soil test, and distances from roads, property lines, residences, wells, etc., and proposed rates of application. Contact the local Department of Natural Resource office or state environmental agency for additional information.

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¹² Wolkowski, R., and A. Crosby, Sensitivity of earthworms to Type X gypsum drywall under controlled environmental conditions



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