Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

AMENDING SOIL PROPERTIES WITH GYPSUM PRODUCTS

Code 333

(Ac.)

DEFINITION

Using gypsum- (calcium sulfate dihydrate) derived products to change the physical and/or chemical properties of soil.

PURPOSE

- Improve soil health by improving physical/chemical properties and increasing infiltration of the soil.
- Improve surface water quality by reducing dissolved phosphorus concentrations in surface runoff and subsurface drainage.
- Improve soil health by ameliorating subsoil aluminum toxicity.
- Improve water quality by reducing the potential for pathogens and other contaminants transport from areas of manure and biosolids application.

CONDITIONS WHERE PRACTICE APPLIES

- This practice applies where land application of gypsum products will be used to alter the physical and/or chemical characteristics of soil to help achieve one of the above purposes.
- To remediate sodic soils, use Conservation Practice Standard (CPS) Code 610, Salinity and Sodic Soil Management.

CRITERIA

General Criteria Applicable to All Purposes

Do not apply gypsum products in watersheds where sulfate additions are restricted.

Validation of product.—It is the responsibility of the amendment provider to furnish chemical analysis documentation for the product to the producer. The chemical analysis documentation will include the calcium and sulfur content and content of heavy metals and all other potential contaminants listed in table 1.

Concentrations of potential contaminants cannot exceed maximum allowable concentrations listed in table 1. In addition, the radium-226 concentration in the gypsum-derived product cannot exceed 10 picocuries per gram (pCi/g).

Flue gas desulfurization (FGD) gypsum that is produced by forced-oxidation wet systems after the removal of fly ash is acceptable for these uses.

The prescribed minimum application rates are based on a calcium sulfate dihydrate equivalency of 100 percent. Application rates for products that are less than 100 percent calcium sulfate dihydrate equivalence should be adjusted accordingly.

Table 1. Screening values for elements in gypsum-derived products for use as a soil amendment.

Symbol (Element)	**Units** gram (g) kilogram (kg) milligram (mg)	**Screening Value for Gypsum-Derived Products**	**Comment**
Ag (Silver)	mg kg^{-1}	…	No limit required
Al (Aluminum)	g kg^{-1}	…	No limit required
As (Arsenic)	mg kg^{-1}	13.1	...
B† (Boron)	mg kg^{-1}	200.†	…
Ba (Barium)	mg kg^{-1}	1000.	…
Be (Beryllium)	mg kg^{-1}	2.5	…
Ca (Calcium)	g kg^{-1}	…	Ca fertilizer; no limit required
Cd‡ (Cadmium)	mg kg^{-1}	1.0	…
Co (Cobalt)	mg kg^{-1}	20.	…
Cr(III) (Chromium)	mg kg^{-1}	100.	…
Cu (Copper)	mg kg^{-1}	95.	…
Fe (Iron)	g kg^{-1}	…	No limit required
Hg (Mercury)	mg kg^{-1}	2.5	…
Mg (Magnesium)	g kg^{-1}	…	Mg fertilizer; no limit required
Mn (Manganese)	mg kg^{-1}	1500.	…
Mo (Molybdenum)	mg kg^{-1}	10.	…
Ni (Nickel)	mg kg^{-1}	100.	…
Pb (Lead)	mg kg^{-1}	30.	…
S* (Sulfur)	g kg^{-1}	220.	S fertilizer; *limit access to ruminants
Sb (Antimony)	mg kg^{-1}	1.5	…
Se (Selenium)	mg kg^{-1}	50.	…
Sn (Tin)	mg kg^{-1}	…	No limit required
Tl (Thallium)	mg kg^{-1}	1.0	…
V (Vanadium)	mg kg^{-1}	136.	…
Zn (Zinc)	mg kg^{-1}	125.	…

† Should not apply greater than 0.9 lb. hot water soluble B/acre with gypsum amendment application rate.
‡ Cd is 1% of Zn limit to restrict food-chain risks of soil Cd.
* Prevent ruminant livestock from ingesting gypsum from storage piles; prevent grazing on amended pastures until one rainfall (or irrigation) event to wash forage.

Gypsum-derived products must have a particle size less than 1/8 inch. Fluid application is acceptable.

Do not exceed annual application rates of 5 tons/acre for the purposes defined in this standard. Use a soil analysis no older than 1 year that provides cation exchange capacity (CEC), calcium, magnesium, pH, and phosphorus, as a minimum, to plan the appropriate application rate of the gypsum products.

Additional Criteria to Improve Soil Health by Improving Physical/Chemical Properties and Increasing Infiltration of the Soil.

Gypsum may be applied to pastures anytime livestock are not present. Do not allow livestock reentry until the gypsum products have been removed from the vegetation by rainfall/irrigation.

Use tables 2a and 2b to determine the application rate of gypsum products when slow infiltration and percolation due to poor aggregation is caused by an imbalance between calcium and magnesium.

CEC is an indirect indicator of clay and organic matter content of soil and is related to how adjustment is needed when certain cations are excessive or deficient. The saturation ranges in table 2a represent optimal cation availability for good soil structure as well as plant and biological use.

Table 2a: Target ranges for base saturation of cations to improve soil chemical and physical properties.

Base Saturation	Balanced
Calcium	70–80%
Magnesium	10–13%
Potassium	2–5%
Hydrogen	1–10%

Of the cations listed in table 2a, calcium and magnesium have the greatest impact on soil structure. Lower CEC soils that tend to be droughty would prefer calcium at the lower end of the range and magnesium to be at the higher end. Higher CEC soils tend to perform best with calcium at mid-to-high range and magnesium at the lower end of the range. (NOTE: Amendment tables based on electrical conductivity for addressing saline and sodic soils are not addressed in this standard. See CPS Code 610, Salinity and Sodic Soil Management.)

Table 2b lists recommended annual application rates based on CEC. Multiple applications at the recommended rates will improve soil chemical and physical properties in a reasonable time without creating soil nutrient imbalances. Once the ratios shown in table 2a are achieved, application rates can be reduced or stopped until soil test values indicate otherwise.

Table 2b: Gypsum application rates to improve soil chemical and physical properties. Goal: Base saturation of calcium = 70 to 80 percent.

CEC	Annual Application Rate (ton gypsum/acre)
<5	0.25
5–10	.5
10–15	1
>15	2

Additional Criteria to Improve Surface Water Quality by Reducing Dissolved Phosphorus Concentrations in Surface Runoff and Subsurface Drainage.

General Use on High Phosphorus Soils.—Apply no less than 1 ton/acre broadcast on the soil surface when soil test phosphorus (STP) is greater than two times the “maximum optimum level” for crop production, or when the P Index rating for the field is **HIGH** or **VERY HIGH**.

Manure Application.—Broadcast no less than 1 ton/acre of gypsum within 5 days after manure application or prior to the next runoff event, whichever occurs first. Mixing gypsum with manure prior to application is acceptable. **CAUTION**: Under anaerobic conditions, gypsum added to liquid manure

storage facilities can result in dangerous levels of hydrogen sulfide emissions. Mixing or agitation of liquid manure with gypsum should not be conducted indoors. Gypsum has also been known to produce excessively high hydrogen sulfide emissions when mixed into outdoor, open-top liquid manure storages.

Additional Criteria to Improve Soil Health by Ameliorating Subsoil Al Toxicity.

When exchangeable aluminum below a 12-inch soil depth is greater than 1.0 milliquivalent/100 mg soil, apply gypsum at a rate recommended by the land grant university (LGU) or the Agricultural Research Service (ARS). Use a soil analysis for aluminum no older than 1 year to plan the appropriate application rate of the gypsum products.

Additional Criteria to Reduce the Potential for Pathogen Transport.

Apply no less than 2 tons/acre of gypsum within 5 days after manure or biosolid application, or prior to the next runoff event after manure application, whichever occurs first.

CONSIDERATIONS

General Considerations.

If soil pH is less than 5, the application of products with high sulfite content may be harmful to plants that are present at the time of application.

Long-term use of gypsum or using rates higher than given in the criteria can have adverse impacts on soil or plant systems. This can include:

- Where gypsum-derived products are alkaline due to impurities, raising the soil pH to a level that is detrimental to plant growth or nutrient balance
- Creating a calcium imbalance with other mineral nutrients such as magnesium and potassium

Additional Considerations for Improving Soil Health by Increasing Infiltration and Improving Physical/Chemical Properties of the Soil.

There is some research that shows gypsum application can increase crop-rooting depth, total root biomass, and nitrogen uptake.

Additional Considerations to Improve Surface Water Quality by Reducing Dissolved Phosphorus Concentrations in Surface Runoff.

Increasing the gypsum application rate beyond that set in Criteria will provide an additional decrease in dissolved phosphorus loss. However, the additional decrease in phosphorus runoff at gypsum rates above 2 tons/acre is not proportional to the additional cost.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared for each field site where gypsum products will be applied. Record practice specifications on CPS Code 333, Amending Soil Properties with Gypsum Products, Implementation Requirement document. Plans and specifications will include:

- The source of the product, e.g., flue gas desulfurization, mined
- Purpose(s) for its use and the planned outcomes
- Chemical analysis of the amendment product
- Soil analyses demonstrating the need for the amendment
- Application methodology, including rates, timing, sequence of application with other nutrient materials (i.e., manures, biosolids, fertilizers), mixing instructions when mixed with manure prior to field application
- Required soil and/or plant analyses after application to determine the effectiveness of the amendment

OPERATION AND MAINTENANCE

Do not allow livestock access to stacked gypsum**.**

Do not resume grazing until rainfall or irrigation has washed gypsum off the vegetation.

Do not apply gypsum after the soil test calcium level exceeds the maximum level established by the LGU.

REFERENCES

Baligar, V. C., R. B. Clark, R. F. Korcak, and R. J. Wright. 2011. Flue Gas Desulfurization Products Use on Agricultural Land. In Donald L. Sparks, editor: Advances in Agronomy. Vol. 111. Academic Press, pp 51-86.

Chaney, R.L. 2012. Food safety issues: Mineral and organic fertilizers. Adv. Agron. 117:51–116.

Chen, Liming, and Warren Dick. 2011. Gypsum as an Agricultural Amendment. Extension Bulletin 945. The Ohio State University. Columbus, OH.

Dungan, R.S., R.L. Chaney, N. Basta, E. Dayton, T. Taylor and C. Davis. 2014. Risk characterization of spent foundry sands in soil-related applications. U.S. EPA Document. Washington, DC.

Endale, D. M., H. H. Schomberg, D. S. Fisher, D. H. Franklin, and M. B. Jenkins. 2013. Flue gas desulfurization gypsum: Implication for runoff and nutrient losses associated with boiler litter use on pastures on ultisols. J. Environ. Qual. 10.2134/jeq2012.0259.

Holmgren, G.G.S., M.W. Meyer, R.L. Chaney and R.B. Daniels. 1993. Cadmium, lead, zinc, copper, and nickel in agricultural soils of the United States of America. J. Environ. Qual. 22:335–348.

Jenkins, M. B., H. H. Schomberg, D. M. Endale, D. H. Franklin, and D.S. Fisher. 2013. Hydrologic transport of fecal bacteria attenuated by flue gas desulfurization gypsum. J. Environ. Qual. 10.2134/jeq2012.0132.

Norton, L.D., and K Donstova. 1998. Use of soil amendments to prevent soil surface sealing and control erosion. Adv. Geoecology 31:581–587.

Shainberg, I., M.E. Sumner, W.P. Miller, M.P.W. Farina, M.A. Pavan, and M.V. Fey. 1989. Use of gypsum on soils. A review. Advances in Soil Science 9:1–111

Smith, D.B., W.F. Cannon, L.G. Woodruff, F. Solano, J.E. Kilburn, and D.L. Fey. 2013. Geochemical and mineralogical data for soil of the conterminous United States: U.S. Geological Survey Data Series 801, 19p. http://pubs.usgs.gov/ds/801/.

Sumner, M.E. Gypsum and acid soils: The world scene. P. 1–32. In D.L Sparks (ed). Advances in Agronomy, Vol. 51. Academic Press Inc, San Diego, CA.

Torbert, H. A., and D. B. Watts. 2013. Impact of flue gas desulfurization gypsum application on water quality in a coastal plain soil. J. Environ. Qual. 10.2134/jeq2012.0422.

U.S. Environmental Protection Agency. 1992. Potential uses of phosphogypsum and associated risks: Background Information Document. EPA-402/R-92-002. U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC.