United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

AMENDING SOIL PROPERTIES WITH GYPSUM PRODUCTS

CODE 333

(ac)

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DEFINITION

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

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Improve water infiltration.
- Improve habitat for soil organisms.
- Improve soil aggregate stability.
- Reduce dissolved phosphorus in surface and ground water.
- Reduce subsoil aluminum toxicity.

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.

This practice does not apply to soils with CEC of less than 5, soils with pH of less than 5.8 (correct pH then re-evaluate), soils with an extractable Mg less than 200 lb/ac, or organic soils.

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

To remediate sodic soils, use NRCS Conservation Practice Standard (CPS) Salinity and Sodic Soil Management (Code 610).

CRITERIA

General Criteria Applicable to All Purposes

Gypsum-containing 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

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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.

Do not apply gypsum after the soil test calcium level exceeds the maximum level established by a land grant university (LGU).

Apply gypsum to pastures when livestock are not present. Do not allow livestock reentry until the gypsum products have been removed from the vegetation by rainfall or irrigation.

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.

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-containing 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.

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

Symbol (element)	Units: gram (g), kilogram (kg), milligram (mg)	Screening Value for Gypsum-Containing 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.	

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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.	

Additional Criteria to Improve Water Infiltration and Aggregate Stability

Gypsum applications should be surface applied and not incorporated. All planned tillage should be done prior to application. Applications must be part of an overall system that manages residue, tillage, crop rotation and/or cover crops that result in improved soil health.

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.

Cation Exchange Capacity (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%

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.

Table 2b. lists recommended annual application rates of gypsum based on CEC. Multiple applications at the recommended rate 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)
5-10	.5
10–15	1
>15	2

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Additional Criteria to Reduce Dissolved Phosphorus in Surface and Ground Water

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. Use of gypsum bedding creates a greater hazard with potential for high hydrogen sulfide levels when added or mixed with manure resulting in harm to workers and livestock.

CAUTION: Use of gypsum bedding with under-barn manure storage is not recommended. Under anaerobic conditions, gypsum added to liquid manure storage facilities can result in hydrogen sulfide emissions that are dangerous for health and life (i.e., above 100 ppm). Mixing or agitation of liquid manure with gypsum should not be conducted in spaces without adequate ventilation where dangerous levels of manure gases can accumulate. Gypsum has also been known to produce excessively high hydrogen sulfide emissions when mixed into outdoor, open-top liquid manure storages.

Additional Criteria to Reduce Subsoil Aluminum 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 a LGU or the USDA Agricultural Research Service. Use a soil analysis for aluminum no older than 1 year to plan the appropriate application rate of the gypsum products.

CONSIDERATIONS

General Considerations

If the principal goal is plant health and productivity utilize Nutrient Management (CPS 590).

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-containing 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.

Considerations to Reduce Dissolved Phosphorus in Surface and Ground Water

Increasing the gypsum application rate beyond that set in the Criteria section will provide an additional decrease in dissolved phosphorus loss. However, the economic return for reducing phosphorus runoff diminishes at gypsum rates above 2 tons per acre. Additionally, applications made beyond the listed ranges in Table 2b may result in nutrient imbalances and are not recommended.

PLANS AND SPECIFICATIONS

Develop plans and specifications for each field or treatment unit according to the Criteria section requirements above, and Operation and Maintenance section requirements below. Specifications must describe the requirements to apply this practice to achieve the intended

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purpose. Record the following specification components in an approved NRCS CPS Amending Soil Properties with Gypsum Products (Code 333) implementation requirements document:

- The source of the product (e.g., flue gas desulfurization or mined).
- Purpose(s) for its use and the planned outcomes.
- Chemical analysis of the amendment product.
- Soil analyses prior to application demonstrating the need for the amendment.
- Application methodology, including rates, timing, sequence of application with other nutrient materials (i.e., manures, biosolids, fertilizers), and mixing instructions when mixed with manure prior to field application.
- Soil and/or plant analysis after application should continue in conjunction with an overall nutrient management system to determine if additional applications are needed.

OPERATION AND MAINTENANCE

A follow-up soil analysis should be taken at least a year after application to determine the effectiveness of the application.

Restrict livestock access to stacked gypsum.

Resume grazing after rainfall or irrigation has washed gypsum off the vegetation.

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