

Gypsum Effects on Earthworm Populations and Chemistry at Several Network Sites

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Purpose of the “FGD Gypsum in Agriculture Research Network”

- Determine rates and technologies for FGD product use in agriculture
- Evaluate soil chemical and environmental effects of FGD products applied to different soil types to improve productivity
- Document effectiveness of FGD gypsum for improving crop yield
- Compare performance of FGD gypsum and mined gypsum

Network Study Sites

- North Dakota
- New Mexico
- Indiana
- Arkansas
- Alabama (2 sites)
- Ohio
- Wisconsin

Basic Network Study Design

- 2 gypsum materials
 - Flue gas desulfurization (FGD)
 - Mined
- 4 rates
 - Low
 - Medium (presumed optimal rate)
 - High
 - Control (0 rate)
- 4 replications

Earthworm Sampling in Network Studies

- FGD gypsum at high rate
- Mined gypsum at high rate
- Control (0 rate)
- 4 replications
- Sample 12 plots in each study

Sampling Procedure

- 2 sample points per plot
- Remove block of soil
 - 30 cm x 30 cm x 10 cm deep
 - Hand sort earthworms from soil blocks in lab
- Extract with mustard solution
 - Pour 3 L of solution in hole left by soil block
 - Collect earthworms expelled by mustard
 - (Rinse worms in water and put in jar with moist paper towels)



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Earthworm Handling for Chemical Analysis

- Not depurated
 - Kill immediately after extraction from soil
 - Ingested soil remains in gut
 - Sample = earthworm tissue + ingested soil
- Depurated
 - Put worms in jars with moist paper after extraction from soil
 - Hold for 48 hr; ingested soil passes from gut
 - Sample = earthworm tissue only

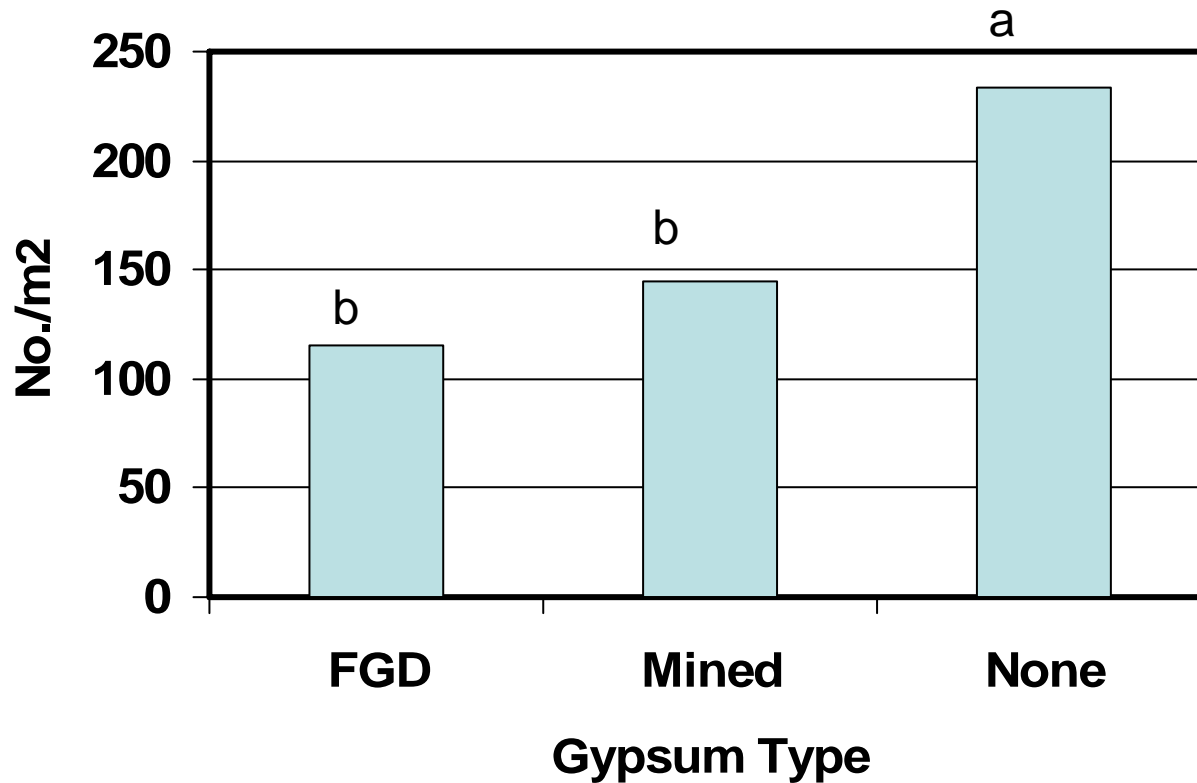
Network Sites Sampled

- Mill Creek Farm (Canfield, OH)
 - Pasture on Wooster silt loam soil (acid subsoil)
- Kingman, IN Farm (Fountain County)
 - Corn-soybean rotation
 - Ragsdale silty clay loam and Yeddo silt loam (water infiltration and surface runoff)
- Sand Mountain Research Center (Crossville, AL)
 - Bermudagrass pasture on Hartsells fine sandy loam
 - Reduce P runoff from poultry manure; acid subsoil

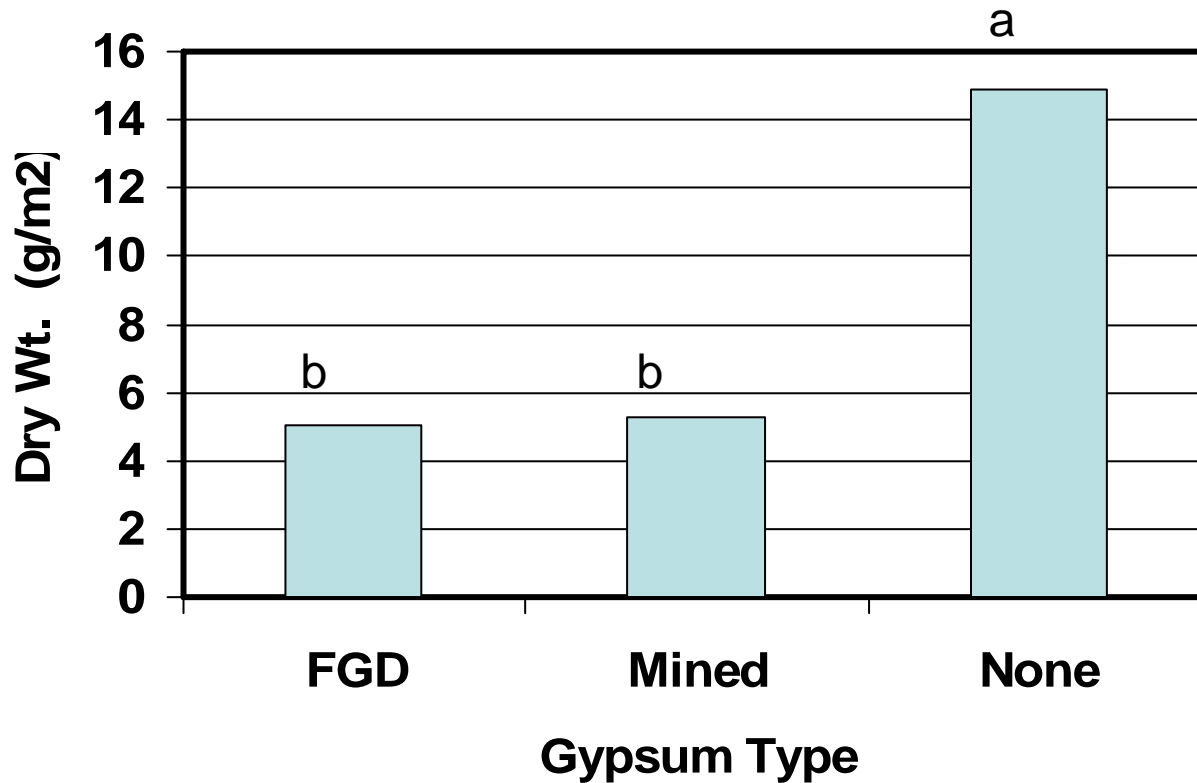
Mill Creek Farm (Canfield, OH)

- Pasture (reed canarygrass, tall fescue, timothy, orchardgrass, birdsfoot trefoil, white clover)
- Wooster silt loam (acid subsoil)
- Gypsum rates (0, 0.2, 2, and 20 Mg/ha)
- Gypsum applied – May 23, 2008
- Earthworms sampled – October 20, 2008

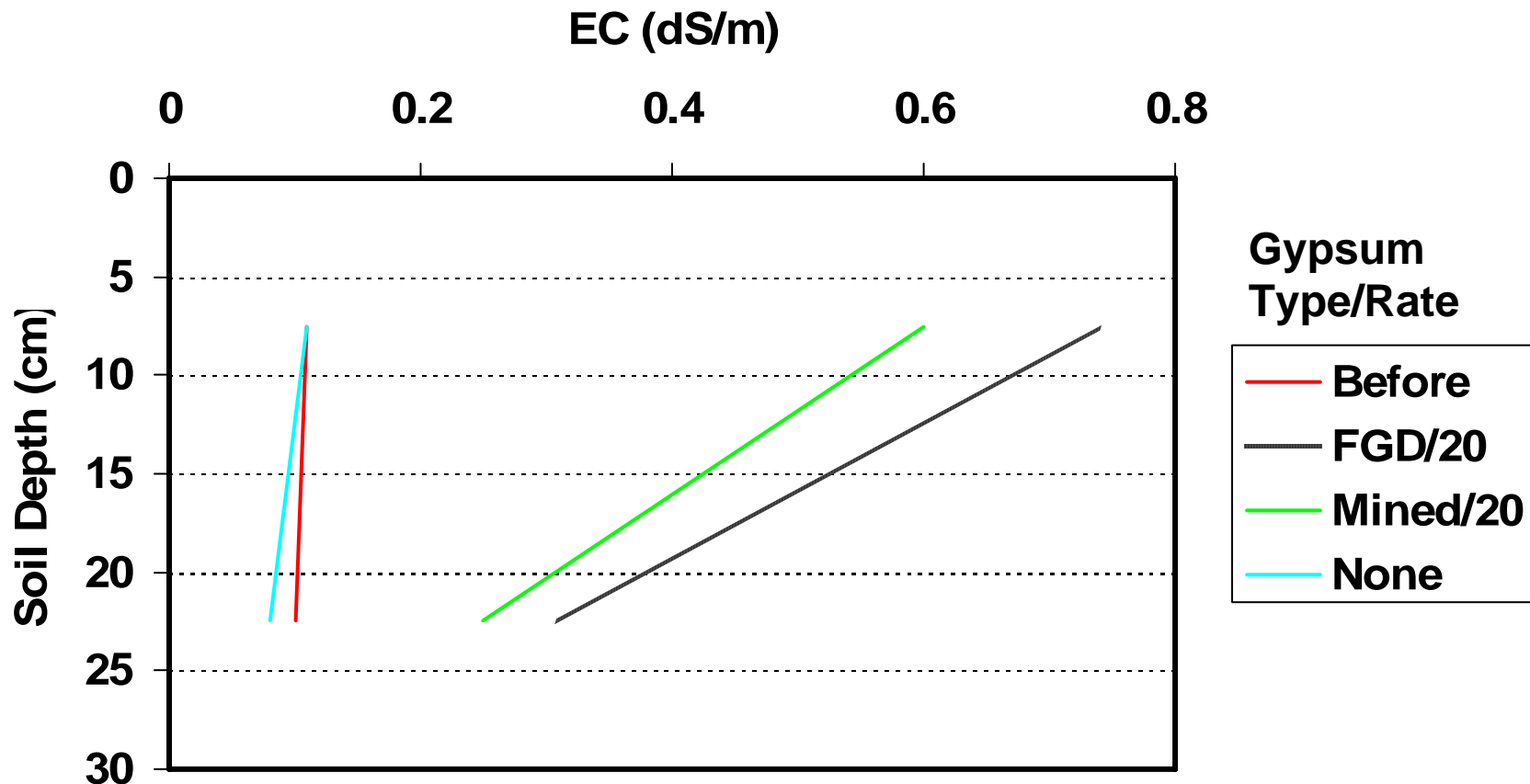
Earthworm Population Density Mill Creek Farm, Ohio



Earthworm Biomass Mill Creek Farm, Ohio



Soil EC before treatment and 1 year after gypsum amendments

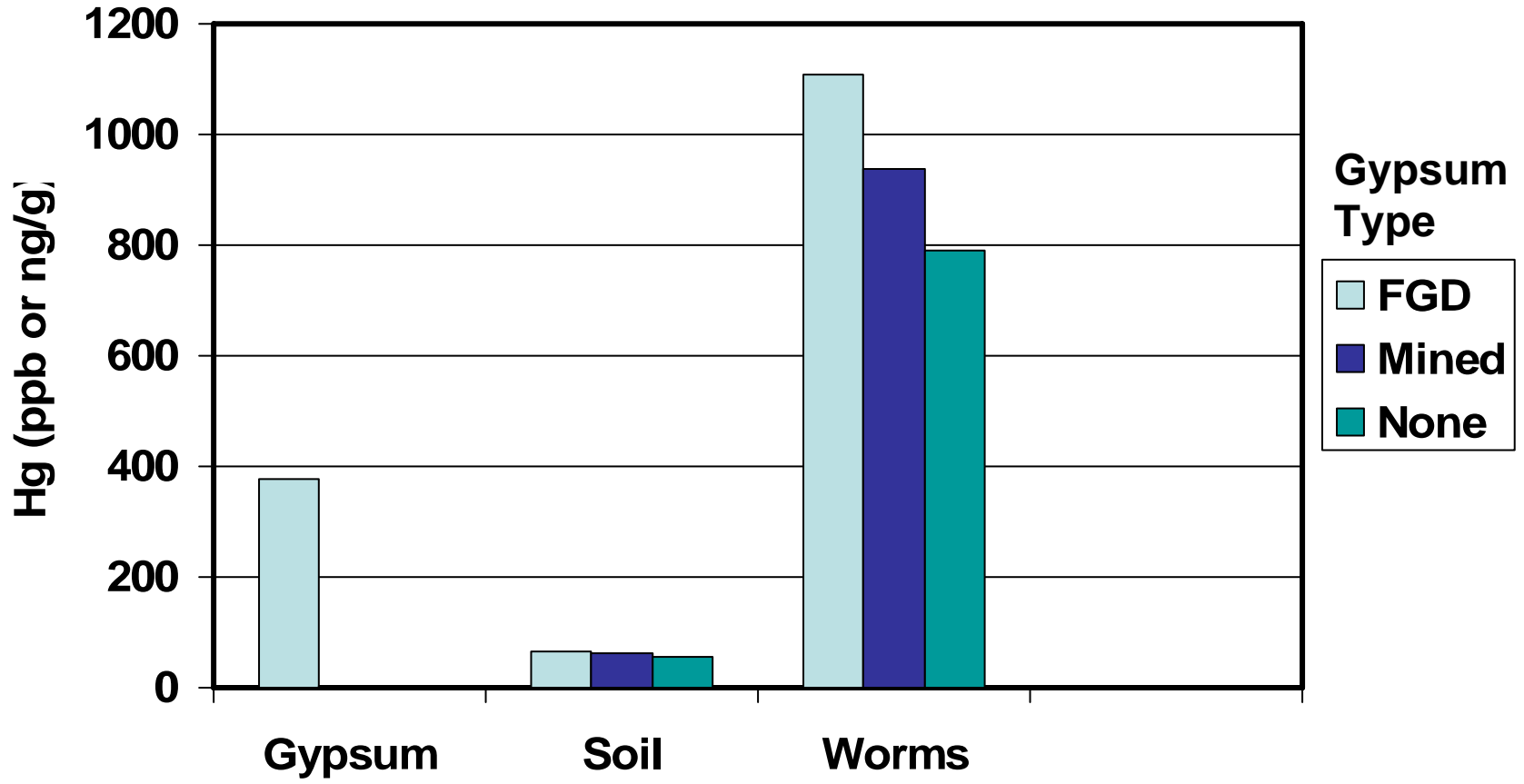


Hg in Gypsum, Soil, and Worms Mill Creek Farm, Ohio (ppb or ng/g)

Treatment	Gypsum	Soil	Worms
FGD	376.1	65.8	1107
Mined	2.7	61.1	939
Control	--	56.7	791

Hg in Gypsum, Soil, and Worms

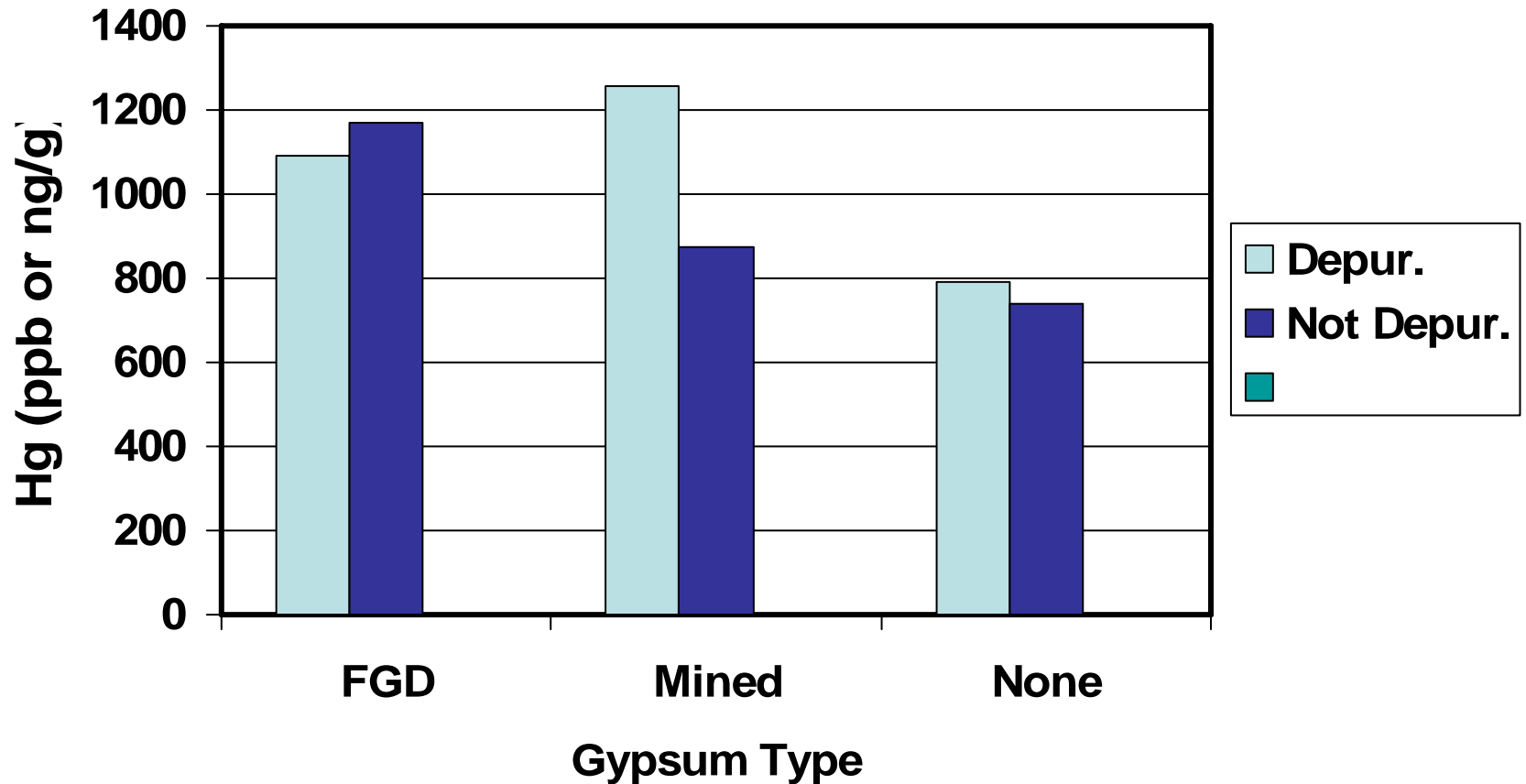
Mill Creek Farm, Ohio



Mined gypsum = 2.7 ng/g

Depuration Effect on Hg in Worms

Mill Creek Farm, Ohio

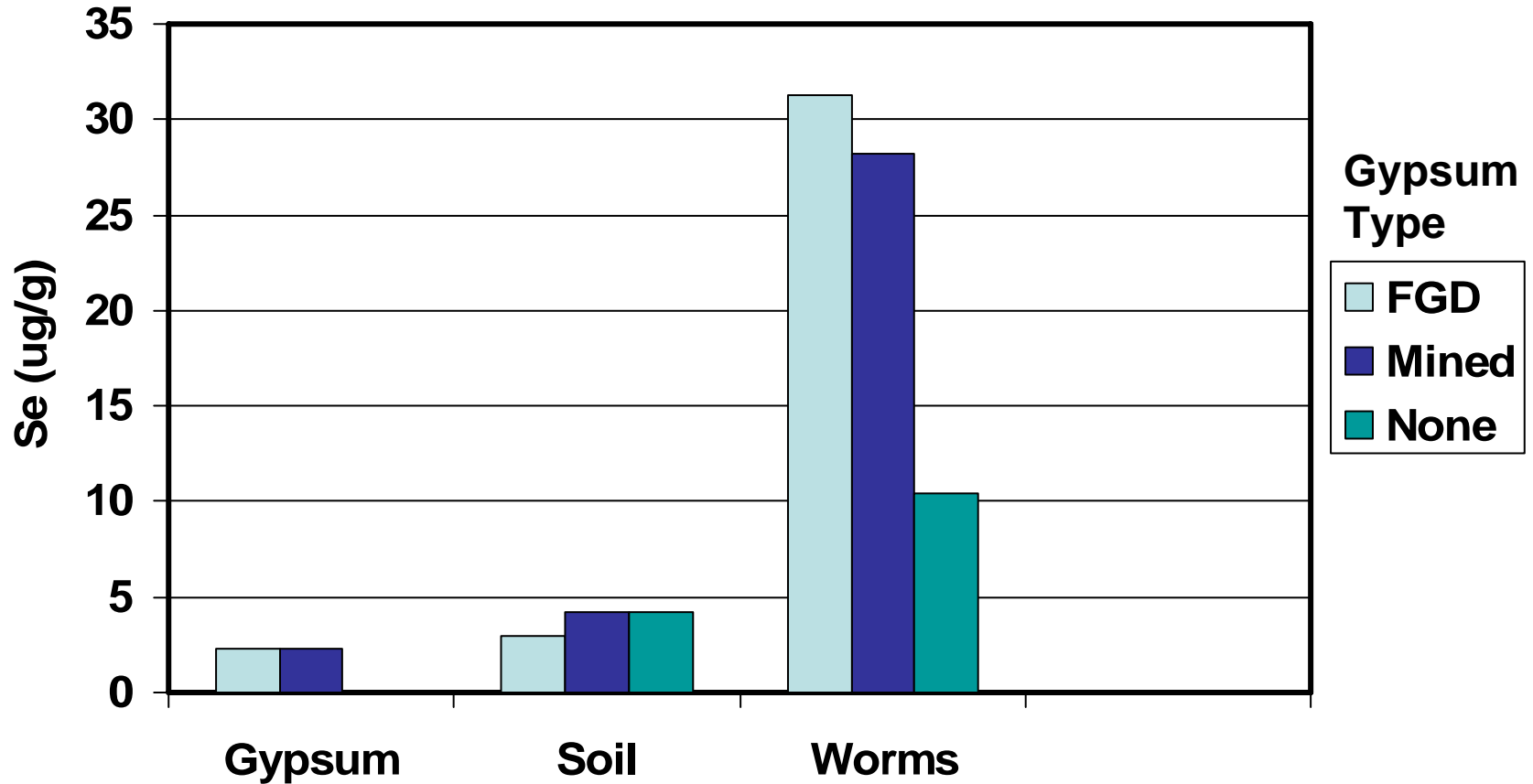


Se in Gypsum, Soil, and Worms Mill Creek Farm, Ohio ($\mu\text{g/g}$)

Treatment	Gypsum	Soil	Worms
FGD	<2.32	2.982	31.31
Mined	<2.32	4.254	28.19
Control	--	4.212	10.40

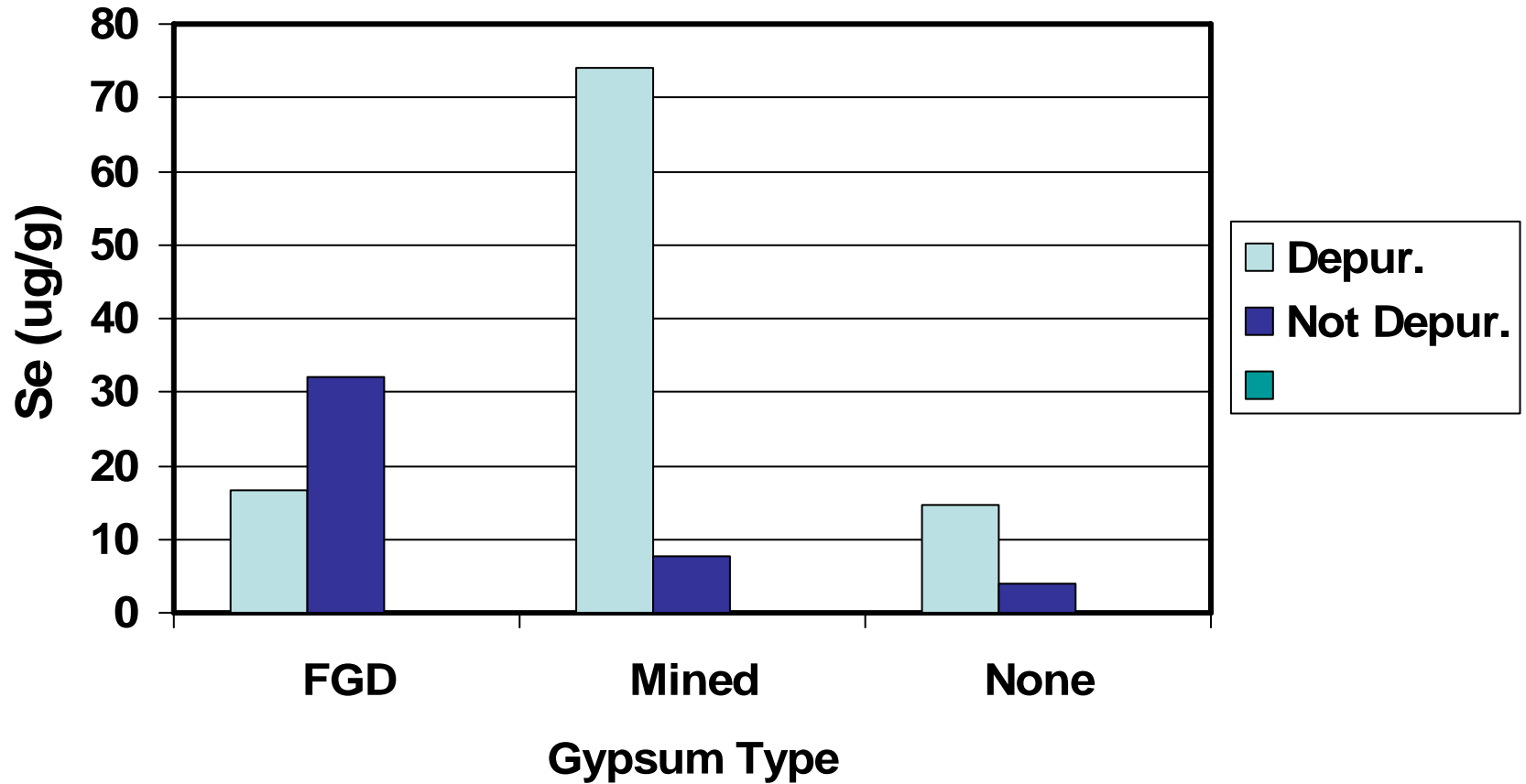
Se in Gypsum, Soil, and Worms

Mill Creek Farm, Ohio



Depuration Effect on Se in Worms

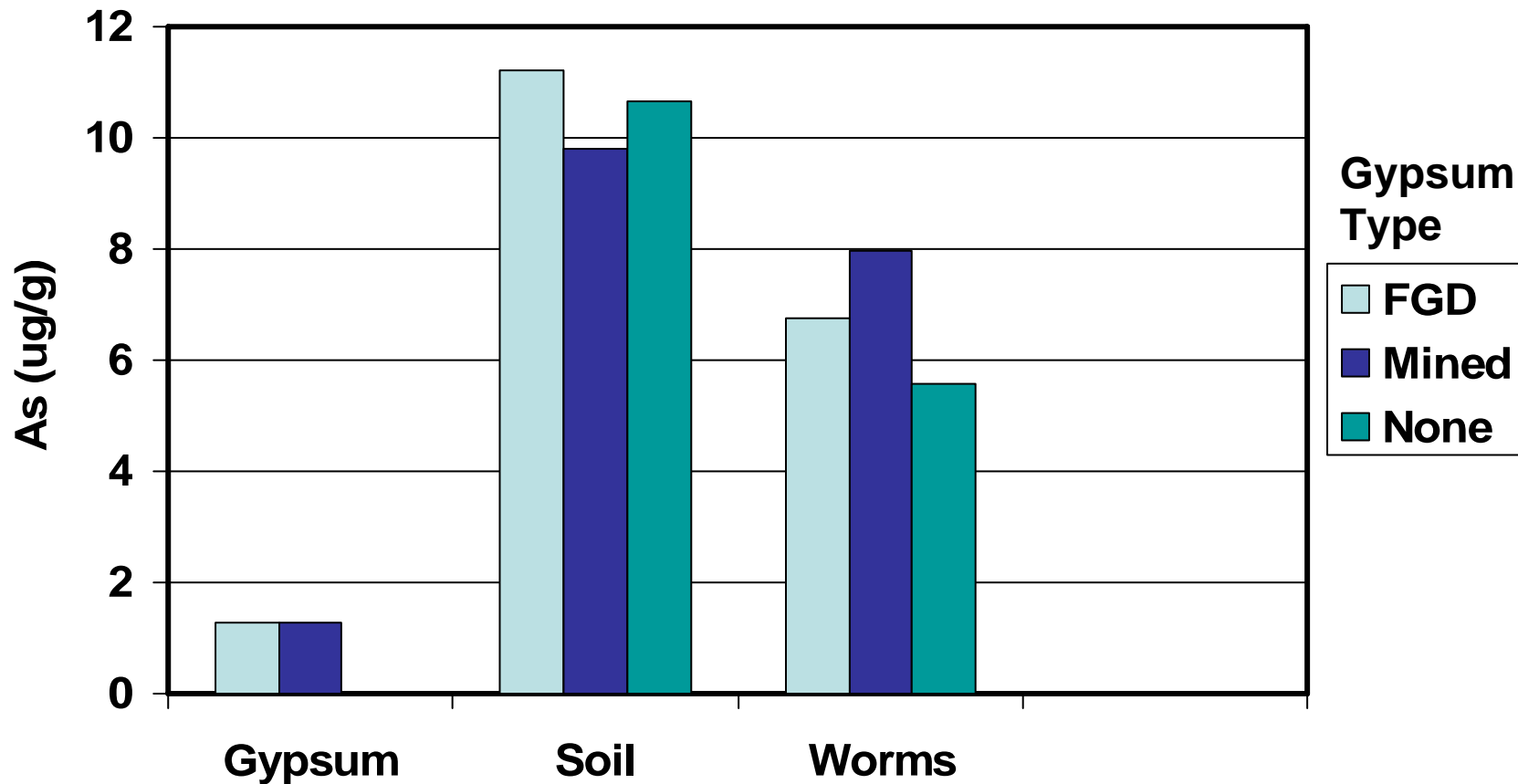
Mill Creek Farm, Ohio



As in Gypsum, Soil, and Worms Mill Creek Farm, Ohio ($\mu\text{g/g}$)

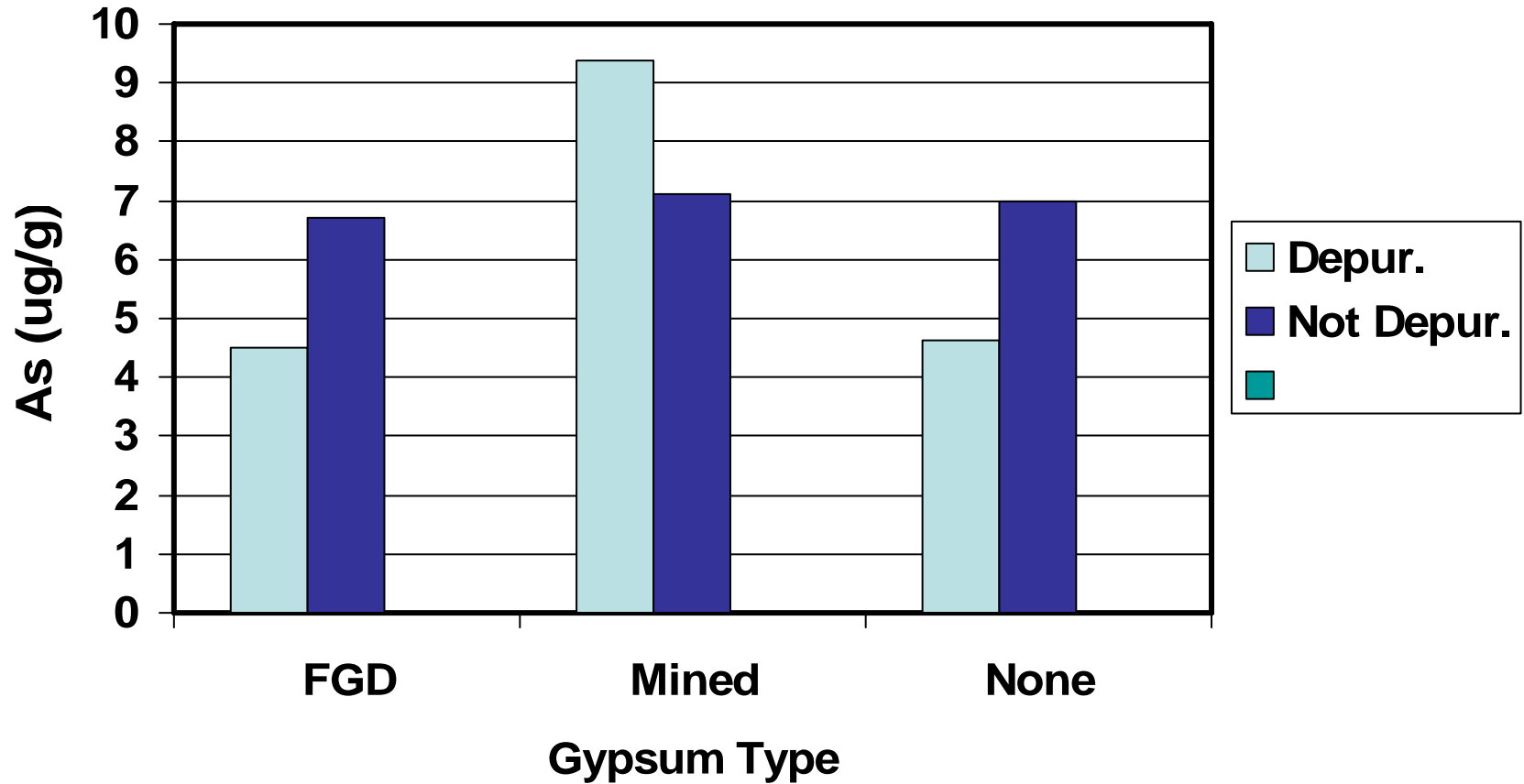
Treatment	Gypsum	Soil	Worms
FGD	<1.284	11.212	6.738
Mined	<1.284	9.793	7.961
Control	--	10.644	5.580

As in Gypsum, Soil, and Worms Mill Creek Farm, Ohio



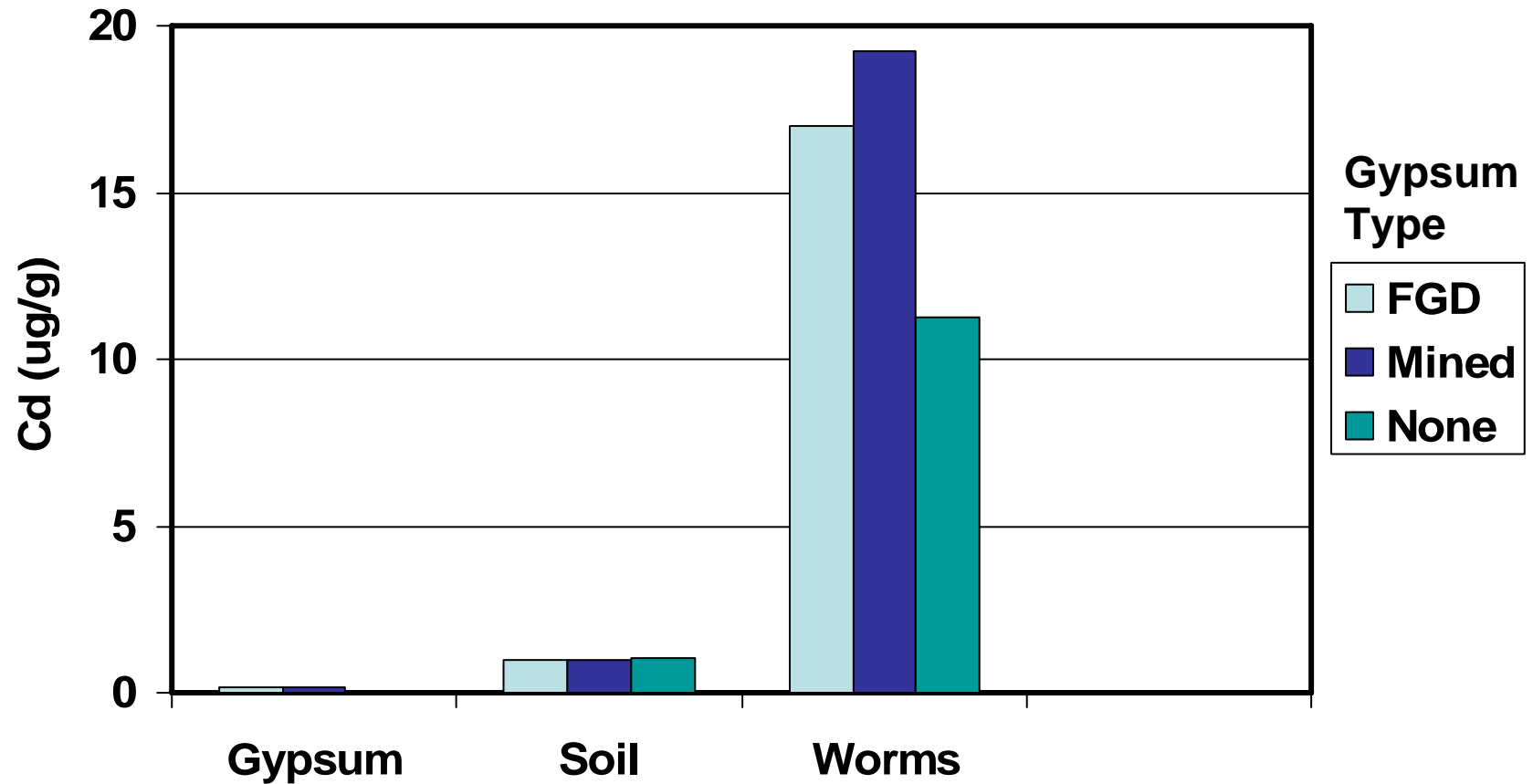
Depuration Effect on As in Worms

Mill Creek Farm, Ohio



Cd in Gypsum, Soil, and Worms

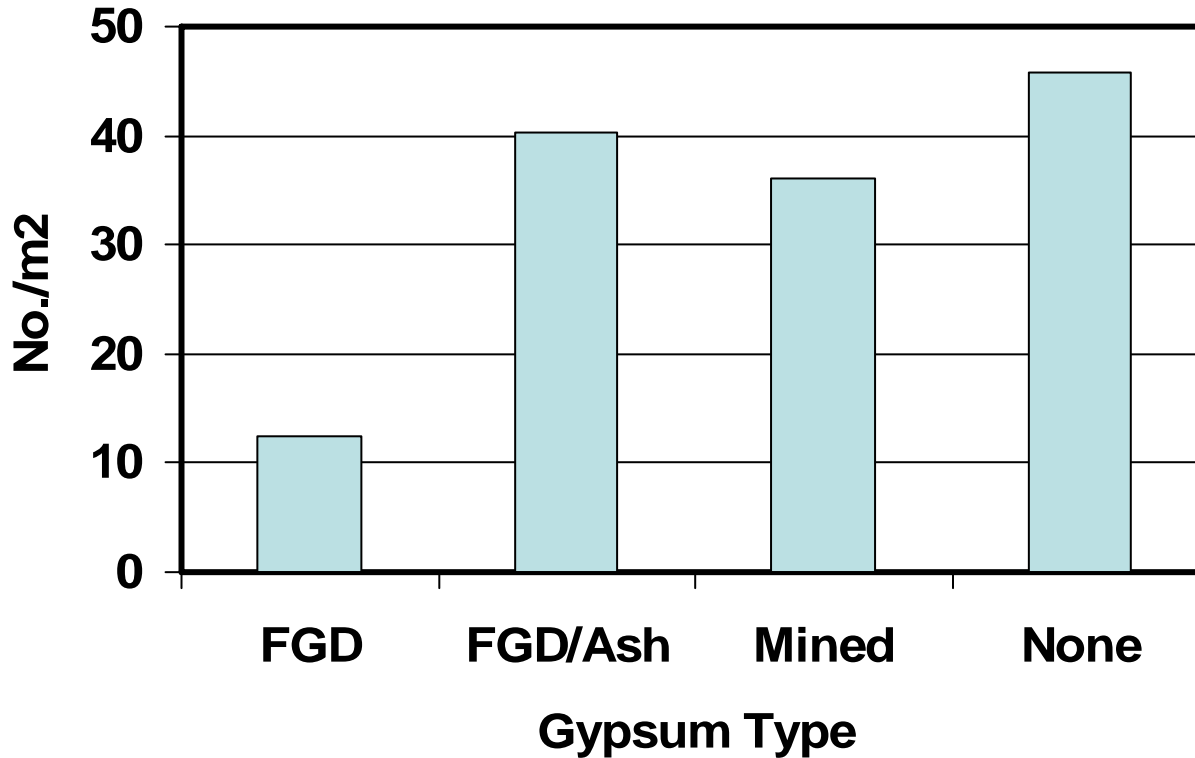
Mill Creek Farm, Ohio



Sand Mountain Research Center (Crossville, AL)

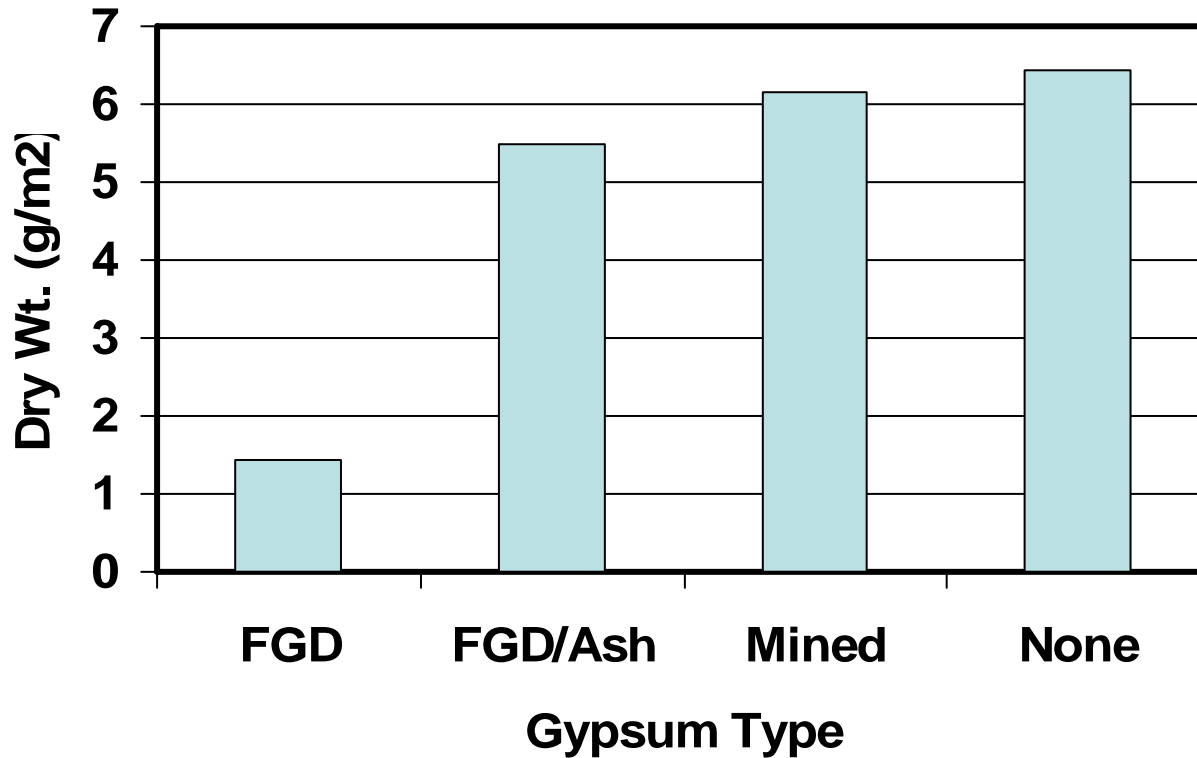
- Bermudagrass pasture
- Hartsells fine sandy loam (acid subsoil)
- Poultry litter (8.9 Mg/ha) as N source - applied May 20, 2008
- 3 gypsum types
 - FGD with fly ash, FGD without fly ash, Mined
- Gypsum rates (0, 2, 10, and 20 Mg/ha)
- Gypsum applied – May 21, 2008
- Earthworms sampled – April 7, 2009

Earthworm Population Density Sand Mountain Res. Center, AL

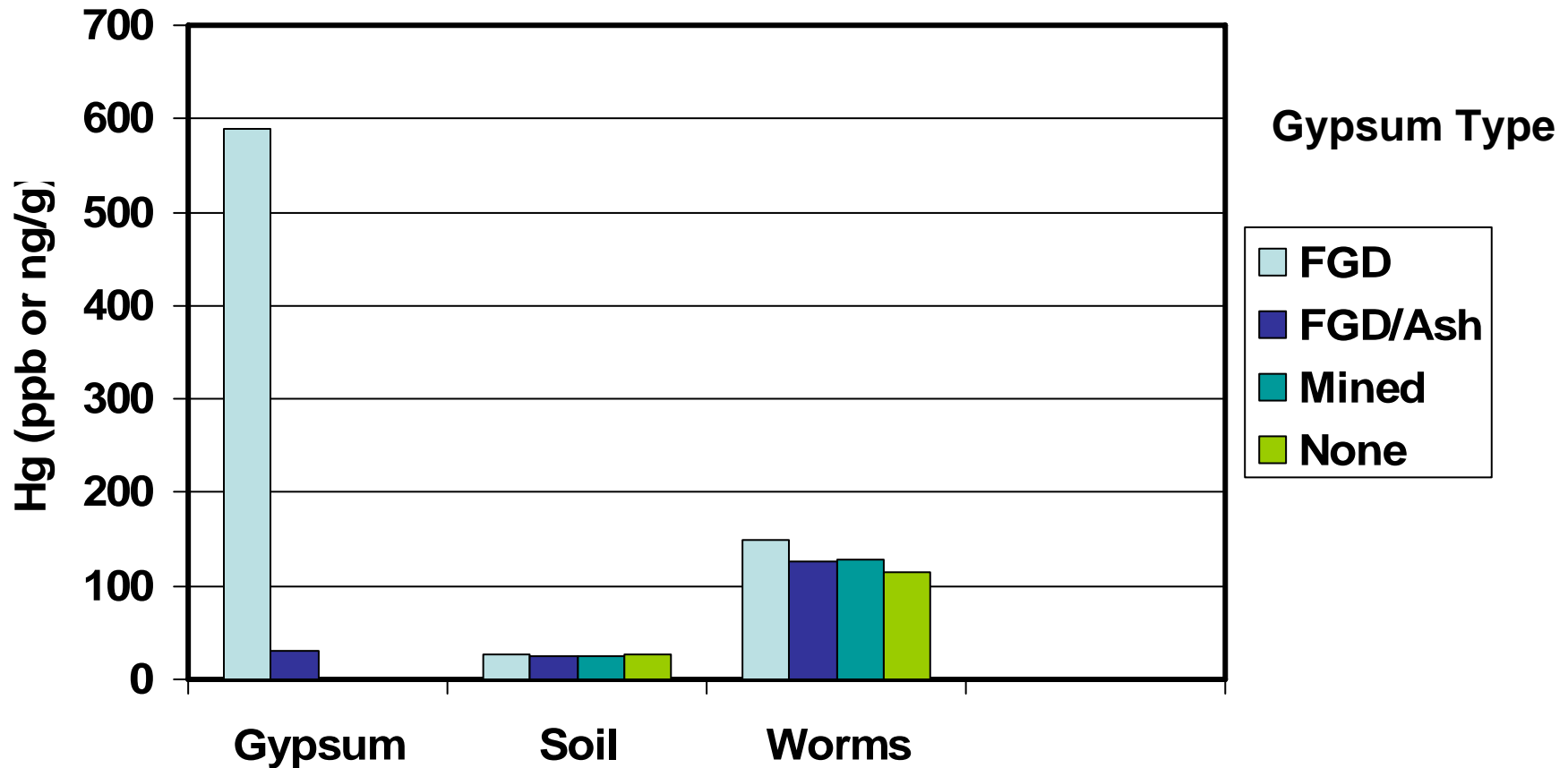


Earthworm Biomass

Sand Mountain Res. Center, AL

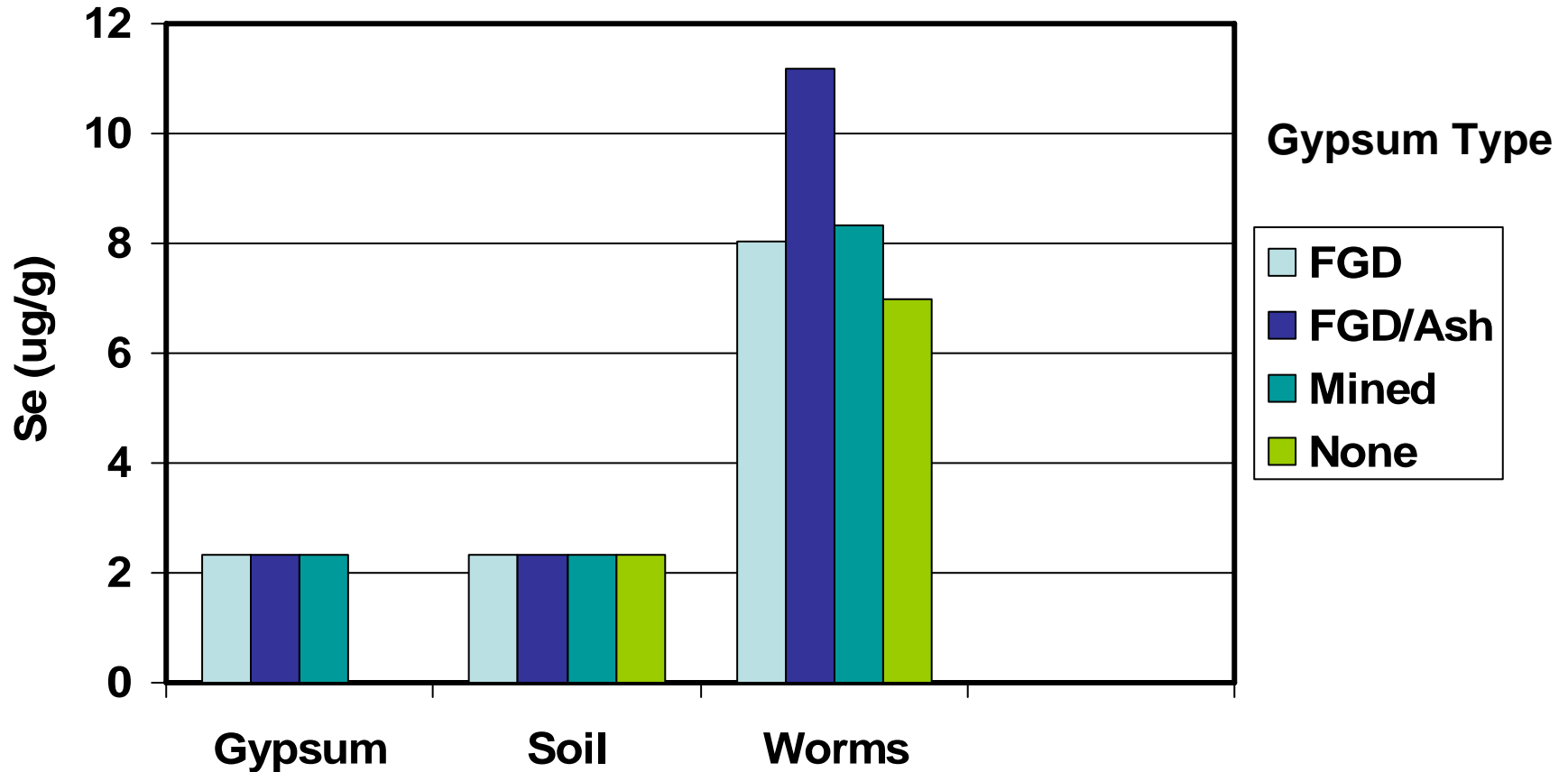


Hg in Gypsum, Soil, and Worms Sand Mountain Res. Center, AL

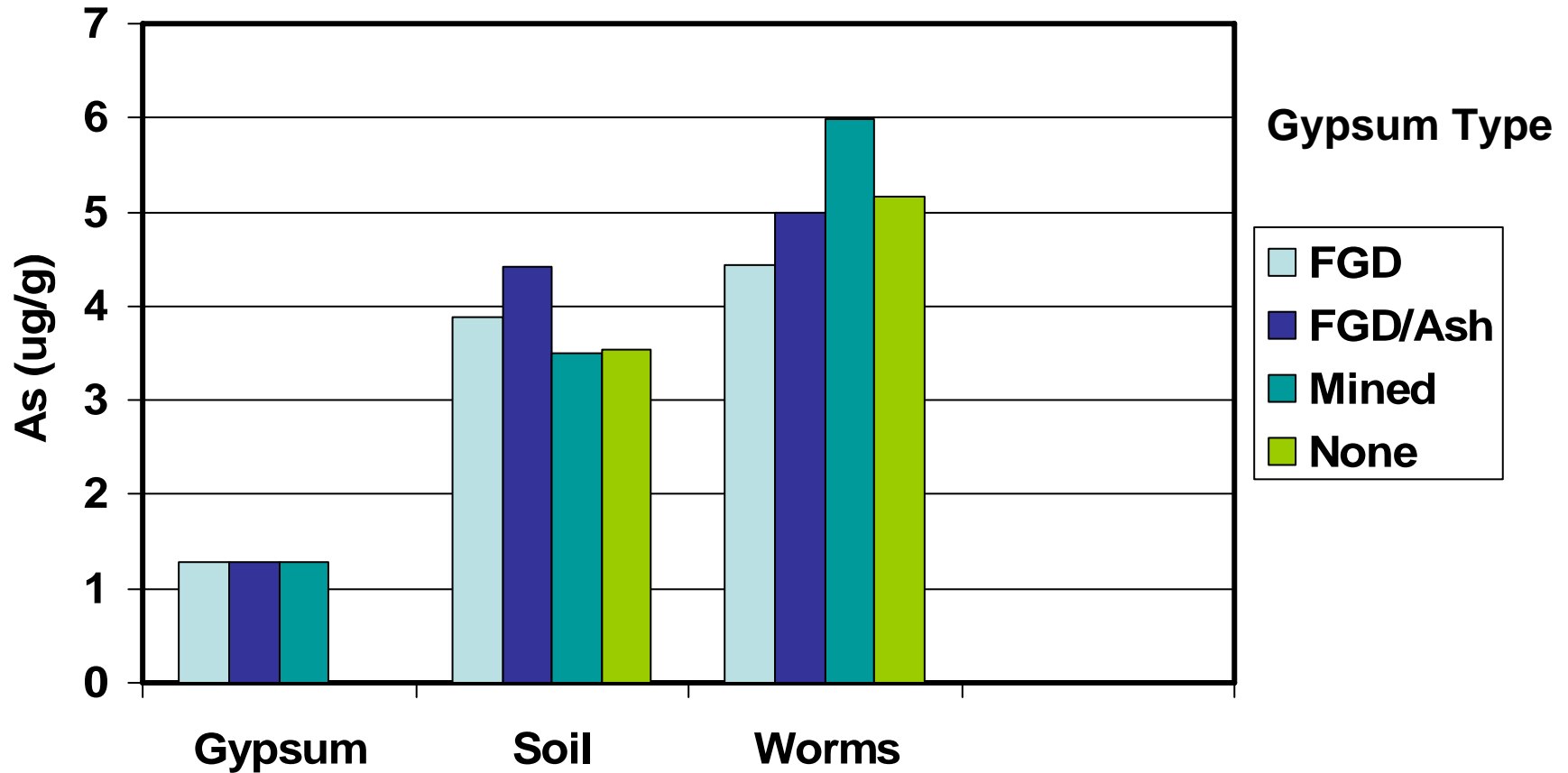


Mined gypsum = 0.85 ng/g

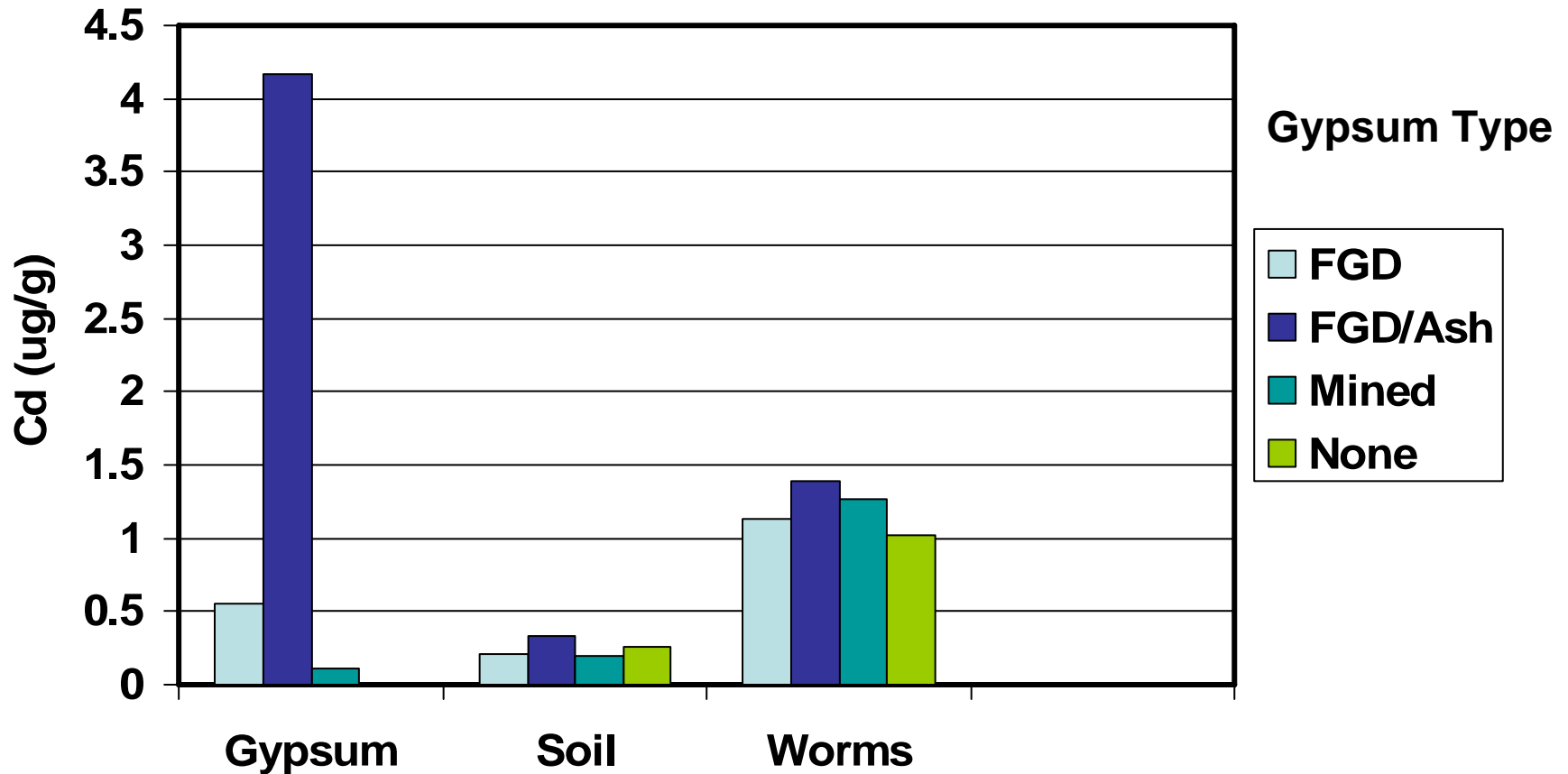
Se in Gypsum, Soil, and Worms Sand Mountain Res. Center, AL



As in Gypsum, Soil, and Worms Sand Mountain Res. Center, AL



Cd in Gypsum, Soil, and Worms Sand Mountain Res. Center, AL

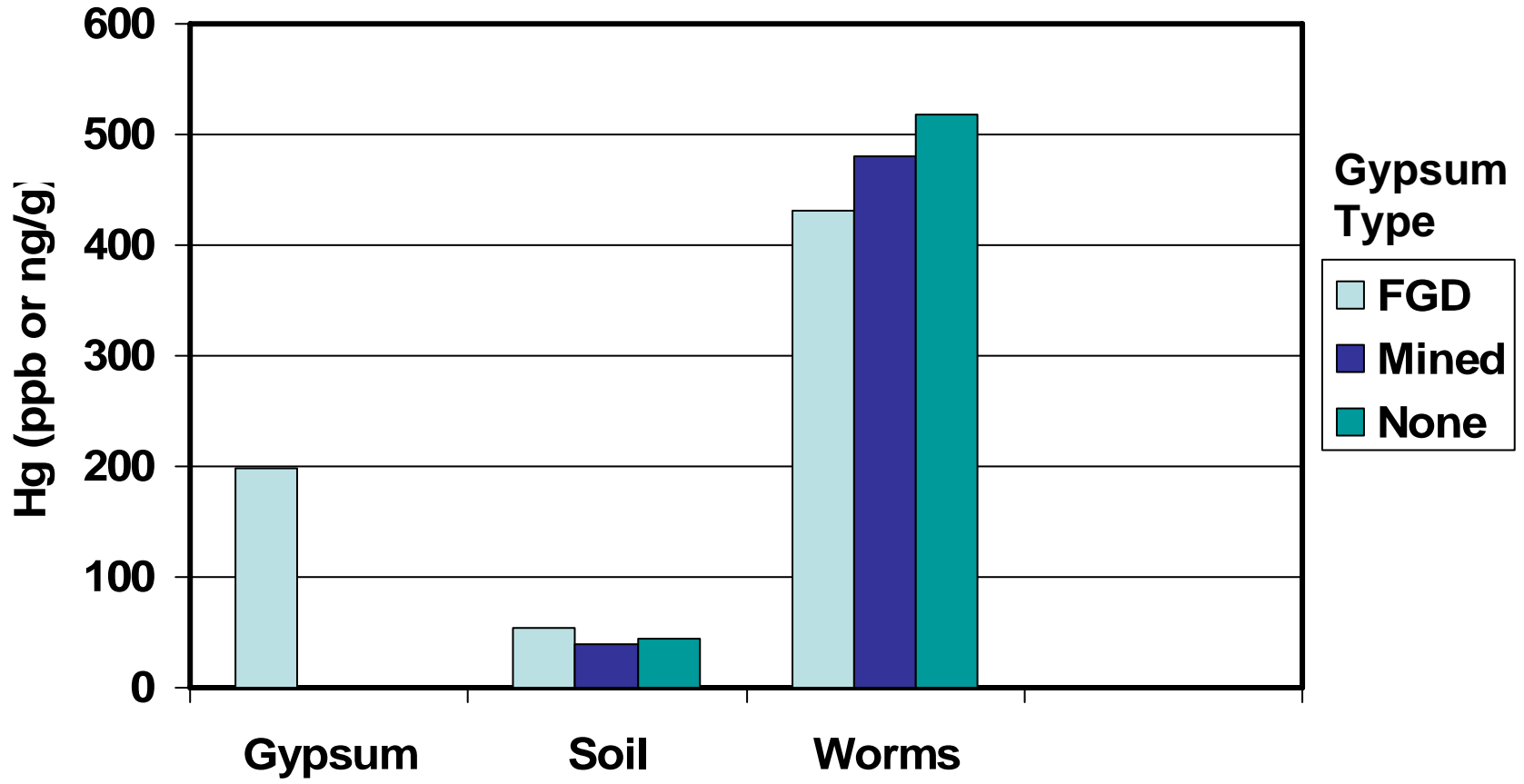


Kingman, IN Farm

(Fountain County, western IN)

- Corn-soybean rotation
- Ragsdale silty clay loam and Yeddo silt loam
- Gypsum rates (0, 0.34, 0.85, and 2.24 Mg/ha)
- Gypsum applied – May 29, 2008
- Earthworms sampled – Dec. 2-3, 2008
 - Digging and sorting on site
 - All earthworms were deputed

Hg in Gypsum, Soil, and Worms Kingman, Indiana

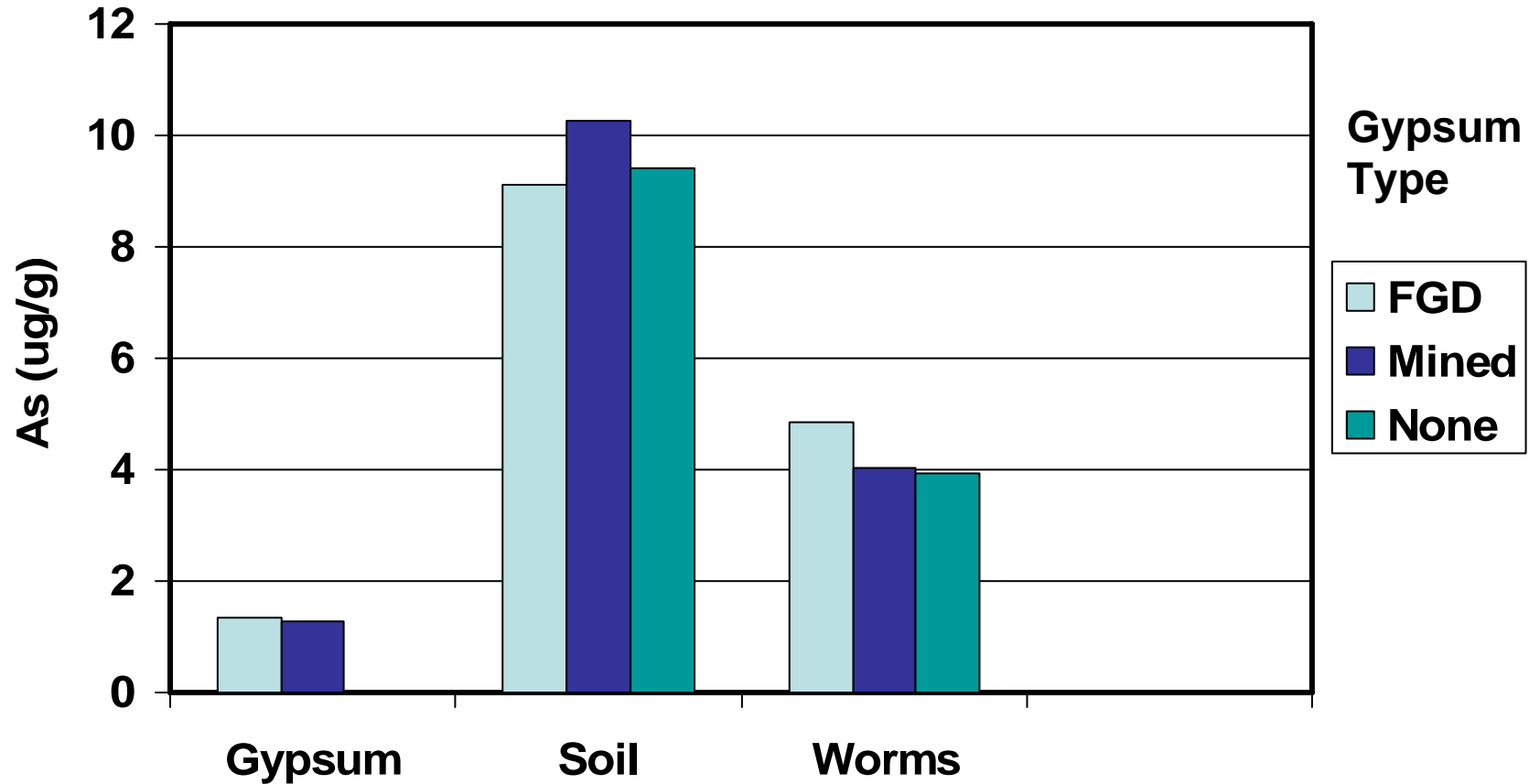


Mined gypsum = 0.10 ng/g

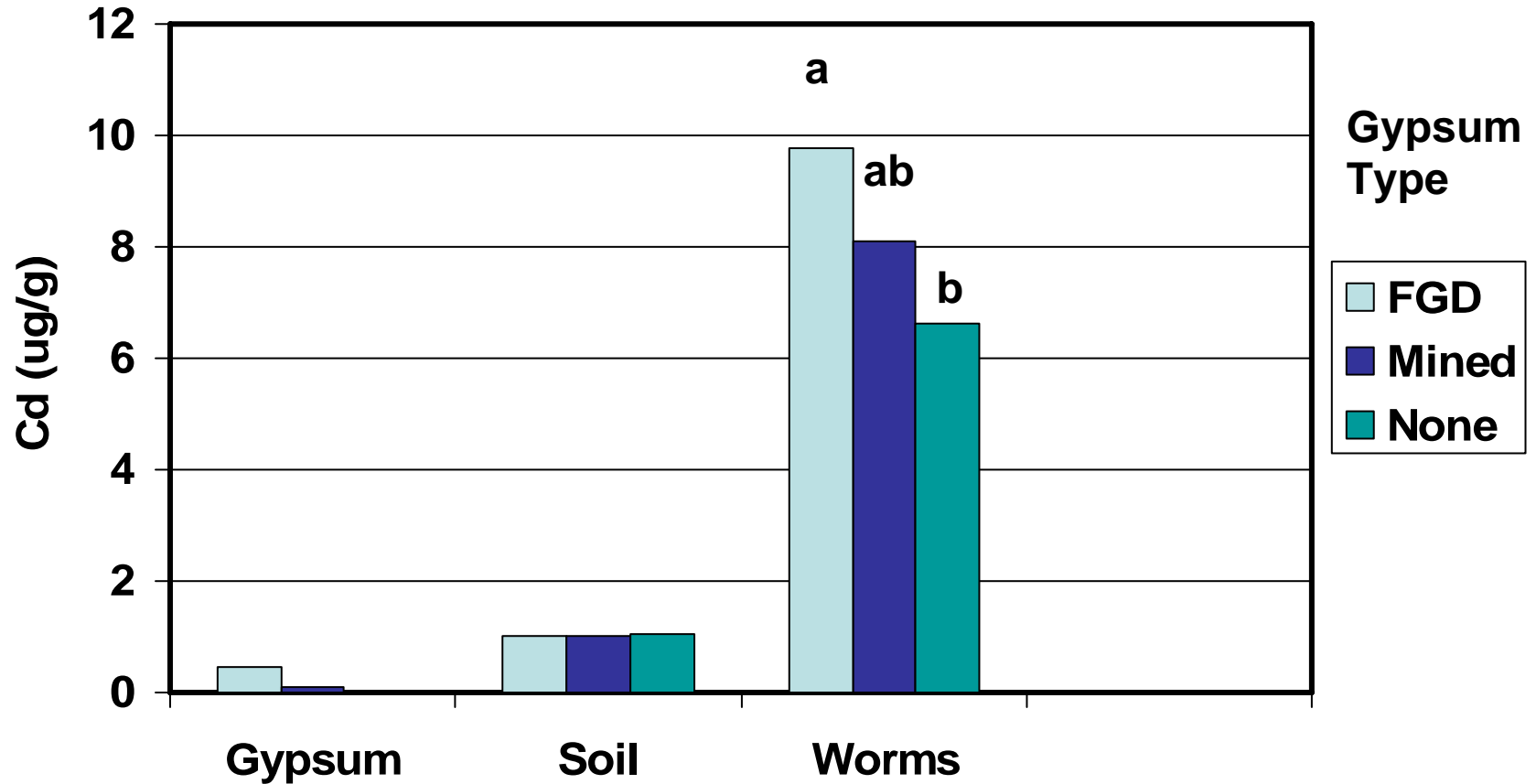
Se in Gypsum, Soil, and Worms Kingman, Indiana



As in Gypsum, Soil, and Worms Kingman, Indiana



Cd in Gypsum, Soil, and Worms Kingman, Indiana



Other Elements

- No significant or meaningful gypsum effects on soil or worm concentrations:
- Cu, Mo, Co, Cr, Ni, Pb, Sr, V, Tl, Zn

Conclusions

- Hg
 - No significant gypsum effects
 - Hg worms > Hg soil
- Se
 - Indiana worms (FGD gypsum > no gypsum)
 - Se worms > Se soil

Conclusions

- As
 - No significant gypsum effects
 - As worms = As soil
- Cd
 - Indiana worms (FGD gypsum > no gypsum)
 - Cd worms > Cd soil