Land Application of Drill Cuttings

Chad J. Penn and Andrew Whitaker
Department of Plant and Soil Science
Oklahoma State University
chad.penn@okstate.edu
Drilling Mud is NOT Fracking Fluids

• All wells produce drilling mud
  – Mud is a by-product of drilling not fracking

• All wells are not fracked

Types of mud

• Water (WBM) and oil based (OBM)
  – WBM uses water as solvent
  – OBM uses diesel as solvent
• Have different characteristics for different purposes in drilling
  – Varies between well, region, and operator
• Typically, WBM is used in the vertical portion of the hole and OBM is used in the curve and horizontal portions
Disposal of drilling mud

- Commercial disposal and reserve pits
  - Essentially buries the waste
- Land application
  - Sustainable alternative to reserve pits
  - Must be properly managed and applied
Risks: WBM

• Salinization of soils
  – Excess salts: reduces the ability of the plant to uptake water.
    • Approximated by EC
    • Remedy: leach out with natural rainfall and time

• Sodic soils
  – excess Na: poor drainage, poor structure, little growth
  • Remedy: gypsum + water

\[
SAR = \frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}
\]
Saline/Sodic Soils
Risks: OBM

• TPH toxicity to plants
  – **Not a long term risk**
    • TPH degraded into CO₂ and H₂O through soil microorganisms
      – Optimize conditions: temp, pH, nutrients, oxygen
      – “Bio-Treatment”
  – Salinization and Sodicity
    • Not as much of a risk as for WBM
Excessive TPH

H₂O
CO₂

+ O₂
+ nutrients
Temp
Moisture
pH

www.alken-murray.com
Metals

• WBM: low to no risk
  – Survey of 90 different WBM samples showed none with excessive metals concentrations

• OBM: low risk
  – Mud survey showed few samples with elevated metals
    • If drilling in areas known to contain geologic material high in certain metals, then mud should be tested
      – Example: Norman drinking water
Rules and Regulations: OK Corporation Commission

• Max 8% slopes
• At least 12 inches of acceptable soil texture
• Must maintain buffer zones (property boundaries, perennial streams, ponds, water wells, etc.)
• E.C. Less than 4,000 µS and E.S.P. less than 10% in receiving soil
• Depth to bedrock, 20 inches for WBM, 40 inches for OBM
• No water table within top 6’ of Soil Profile
• WBM may be re-spread after 3 years has passed and Soil test requirements met
• OBM sites can not be re-used for WBM or OBM
Permissible Loading

- Use Most Limiting Factor Calculations from OK Corporation Commission

  - Must not exceed loading rates

  - 6,000 lbs/ac TDS
  - 3,500 lbs/ac Cl⁻
  - 40,000 lbs/ac TPH
  - 200,000 lbs/ac Dry Weight (For Solids)
Handling of Mud

• OBM is spread only as a solid

  – Must be mixed with bulking agent at a 3 parts agent to 1 part OBM ratio
Handling of Mud

• WBM is spread both in liquid and solid form
## Economics for typical wells

<table>
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<tr>
<th>County</th>
<th>WBM (barrels)</th>
<th>OBM (barrels)</th>
<th>Acres</th>
<th>WBM value ($)</th>
<th>OBM value ($)</th>
<th>Total value ($)</th>
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</tbody>
</table>

Is it worth it?
OBM field plots: TPH degradation

• 3 bulking agents
  – Gypsum, caliche, and lime

• 3 ratios of bulking agent:OBM
  – 3:1, 1.5:1, and 0 (mud alone)

• Manure amendment applied to mud alone and gypsum bulked
  – Plant available N rate (PAN) and 1.5 PAN
TPH Degradation

Day 198% TPH degraded in 72nd 70 days kg⁻¹

- **OBM alone**
  - $y = 15228e^{-0.022x}$
  - $R^2 = 0.9689$

- **1.5 Gypsum:OBM + PAN Manure**
  - $y = 4780.6e^{-0.021x}$
  - $R^2 = 0.8049$

Soil TPH (mg/kg) vs. Time (days)
Forage Yield

You Win!!!

Total Forage Yield (kg/ha)

Treatments

A, AM1, AM2, C, C1, C2, G1, G2, G2M1, G2M1M, G2M2, L1, L2
OBM Conclusions

- TPH degrades quickly by itself
- No need for “additives”
- Metals?
- Relatively low risk of long term negative impact
  - TPH testing at OSU
    - Only 2 water samples in 1.5 years had TPH levels above zero.
WBM Research

• Impact of salts from WBM on wheat and grass
  – Evaluate application timing and rate
    • Lahoma: wheat and grass

• Added WBM at two different rates
  – Evaluated application timing

Application of WBM: 4000 and 6000 lbs of TDS/acre
EC: Day 0 (after application)

Date and Rate of Application

EC (mS/cm)

- Control
- Oct 15-6000
- Oct 16-4000
- Dec 6-6000
- Dec 6-40000
- Jan 14-6000
- Jan 14-4000
- Feb 15-6000
- Feb 15-4000
- Mar 20-6000
- Mar 20-4000

0-3 in vs 3-6 in
EC: August 28th, 2013

Lower application rate = less risk

EC (mS/cm)

0-3 in
3-6 in

Date and Rate of Application
SAR: August 28th, 2013

Date and Rate of Application
You Win!!! (probably)
WBM Conclusions

• Greater risk of causing long term damage compared to OBM
  – i.e. salts don’t degrade

• Soil texture is double edged sword
  – Heavy texture can handle more, but decreases more slowly in SAR

• Rainfall is critical

• If applied correctly, expect no long term soil damage

• Apply to grass when dormant