Saline-Sodic Water Impacts to Soils and Vegetation[1]

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Abstract: Saline-sodic waters derived from coalbed methane (CBM) gas production are being applied to rangelands and production agricultural lands within the Powder River Basin (PRB) of Montana and Wyoming. Impacts from 1 to 4 years of irrigation with saline-sodic waters (EC's = 1.8 to 4.0 dS m^{-1}; SAR =15 to 38) to soil and vegetation were examined on study sites with variable soils, vegetation communities, and water management strategies. Soil chemical and physical parameters (pH, EC, SAR, texture, bulk density, water infiltration rate and Darcy flux rate) from treated (irrigated) sites were compared with those of representative control (non-irrigated) sites at 6 depth intervals to 120 cm. Saline-sodic water applications significantly (P=0.05) increased soil EC values at depths to 60 cm and SAR values to 30 cm. Infiltration rates and Darcy flux were significantly (P=0.10) reduced on treated vs. control sites. Saline-sodic water applications significantly increased both above-ground biomass production and canopy cover of perennial grasses compared to controls on all study sites. Up to 4 years application of CBM waters has significantly altered soil chemical/physical properties, soil water flow dynamics and native vegetation communities, resulting in significant considerations for reclamation potential of these lands.

Additional Key Words: coalbed natural gas, coalbed methane, infiltration rates, hydraulic conductivity, land application.

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Introduction

Active coalbed methane (CBM) exploration and production is occurring in the Powder River Basin (PRB) with over 20,000 wells permitted or drilled and more than 50,000 future wells projected (WY Oil and Gas Conservation Commission, 2003). CBM production requires extensive coal seam dewatering and results in large water volumes being directly applied to agricultural and non-cultivated lands with various irrigation systems. Proper management of these waters is required to prevent deterioration of soil chemical/physical properties and reduce sodium (Na^+) influence on clay particle and organic matter dispersion. Successful management strategies encourage:

- Steady infiltration and drainage through the soil profile.
- Minimal surface ponding or crusting.
- Minimal salt-related impacts to soil/vegetation.
- Minimal increases in erosion or anaerobic soil conditions.

Study Region & Site Descriptions

The PRB is located in northeast WY and southeast MT. It is characterized by rolling uplands and hills with rough, eroded-broken terrain in the northern portions (USDOI-BLM, 2003). Soils from 6 treated (irrigated) study sites and representative, non-treated control sites were sampled early and late season during the 2003 and 2004 field seasons. Two additional sites were added in 2004. Soil data from 2003 and early season 2004 are summarized here. Vegetation data were collected from native plant communities on sites 1 and 3 during the 2003 field season and sites 1, 3, 6, 7 and 8 during 2004.

CBM water quality on the study sites ranged between 1.4-4.0 dS m^{-1} (EC) and 15-38 (SAR) in 2003 and 1.6-4.9 dS m^{-1} (EC) and 18-57 (SAR) in 2004. These values exceed those generally recommended for irrigation use.

Soil Impacts

EC and SAR

Chemical analyses (2003) indicated soil EC values on irrigated sites were significantly greater (P=0.05) than control sites in the upper 60 cm (Ganjegunte et al., 2005). SAR values were also significantly greater in the upper 30 cm of most irrigated sites suggesting Na^+ build-up.

Infiltration

Infiltration rates on treated sites were consistently slower than those of their representative control sites throughout 2003 and May 2004. Differences were significant (P=0.05) at treated sites 1, 2, 4, and 6 and significant (P=0.10) on treated sites 3 and 5 in October 2004.

Darcy Flux

During 2003, Darcy flux rates were significantly slower (treated vs. control) at site 1 (to 120 cm) and site 4 (to 60 cm). Other treated sites had slower Darcy flux rates (vs. controls) at most depths, but significant trends by depth or site were not apparent. However by 2004, Darcy flux

rates were significantly (P=0.05) lower at most depths on all sites.

Vegetation Impacts

Perennial Grasses--Biomass and Canopy Cover

After 3 to 4 seasons of CBM water application, biomass production and canopy cover of native perennial grasses on treated plots exceeded those of representative controls. However, both parameters decreased on the only 2 sites sampled in both 2003 and 2004. This trend will be further investigated in 2005.

Species Richness

Total species numbers (richness) and total numbers of non-perennial grass species varied among sites in response to environmental variables other than land application of saline-sodic waters. Influences may include CBM water quality/application rates, soil texture, tolerance of dominant vegetation to saline-sodic waters, and nutrient availability. Supplemental fertilization with N, P, K is uncommon on these treated study sites.

Conclusions

Land application of saline-sodic water (1-4 years) significantly elevated soil EC and SAR at depths to 60 and 30 cm, respectively.

- Infiltration and Darcy flux rates significantly decreased with saline-sodic water application.
- Saline-sodic water application increased native perennial grass production and cover relative to control sites.

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