Photo 1. Soil fines and crusts.

Photo 2. Soil fines.

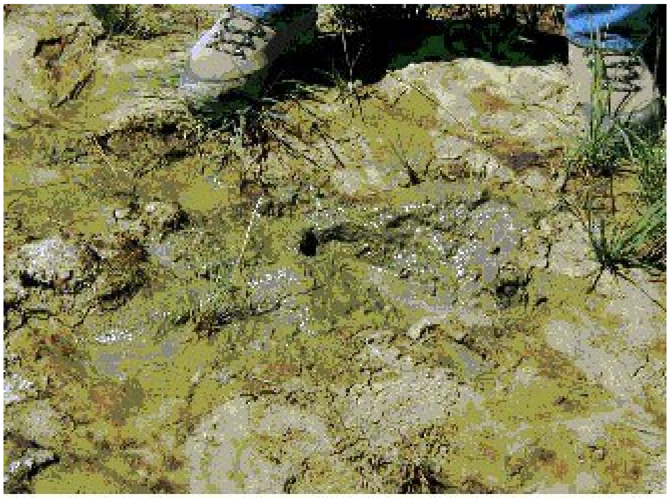

Photo 3. Vegetation loss in saturated zone.

Photo 4. Marginal dieback of vegetation.

Photo 5. Recent transplants.

Photo 6. Recent transplants.

Photo 7. Channel slumping.

Photo 8. Channel slumping

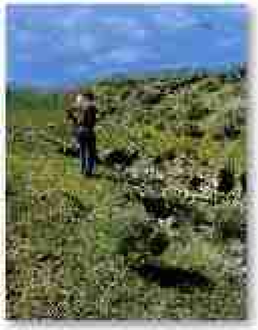

Photo 9. Encrustation possibly from sodic soils.

Photo 10. Saline and sodic deposits.

OFFICE OF THE COORDINATOR
760 West Fetterman
Buffalo, Wyoming 82834
Office 307-684-7614
Cell 307-351-0618
Fax 307-684-5972
seacross@vcn.com

Date of contact : 06 June 2001
Instigator : Phil Gonzalez, LDS Range Conservationist
Responding Mickey Steward and BJ Kristiansen
Location - Buffalo
Phone - 684 2526
Address - 760 W. Fetterman 82834

Topics of Discussion

Soil conditions and transplant status in Burger Draw. See attached.

Comments

I recommend immediate investigations spearheaded by a knowledgeable pedologist specializing in clay mineralogy and pot studies and field trials under the direction of an experienced vegetation expert in reclamation of saline, saturated soils. Suggested general experimental protocols attached.

Commitments

As further requested, by LDSCD, if any.
Deadlines: None

SOIL CONDITION AND TRANSPLANT STATUS IN BURGER DRAW

Introduction

Burger Draw is downcut through the rugged terrain of the Powder River Breaks just south of I-90 at the Dead Horse Creek exit and east of the Powder River, to which it drains. Wasatch clays form the surface substrate and parent material of the soils found in the draw and its surroundings. Burger Draw has numerous small tributaries. CBM water is being discharged to Burger Draw, from whence it flows to the Powder River.

Discharge water in this draw is reported to have SAR in the range of 15 to 30, TDS from 1200 to 2000 ppm, and electrical conductivity approximately equivalent to TDS. Soil pH above the discharge area is around 7.7. Moving downstream, the pH increases to mid-8. Near the confluence of Burger Draw and the Powder River, soil pH is in the low to mid-9. Further information is being collected on soil chemistry.

Soil structure in the saturated portions of the drainage currently appears to be dominated by transported fines (crusted surface covering slimes - Photos 1 and 2). Native vegetation in the saturated zone is dying (Photos 3 and 4), and recently transplanted vegetation (Photos 5 and 6) has failed. Channel areas appear to be susceptible to slumping and transporting (Photos 7 and 8) Both black and white alkali are accumulating in substantial quantities on the soil surface, indicating the development of saline-sodic and sodic soils (Photos 9 and 10). Sodic soils and increased erosion represent difficult management challenges. These issues should be resolved in order to continue discharge of CBM water in this area.

Background

Soil Chemistry

Salt-affected soils are characterized and classified on the basis of chemical properties. Two measurements are involved for the most part: (1) an approximation of the content of soluble salts in the soil, and (2) a measurement of the exchangeable-sodium percentage. On the basis of these determinations, the soil is assigned to one of three classes: saline, which denotes excess soluble salts, sodic, a term indicating that excess exchangeable sodium is found in the soil, and saline-sodic, which recognizes the presence of both conditions (Hausenbuiller 1972).

Accumulating soluble salts tend to increase the content of exchangeable sodium in the soil if the sodium they contain can compete favorably with soluble calcium and magnesium for exchange sites. Because sodium has a low adsorption affinity, it is not particularly competitive unless its concentration exceeds the combined concentration of calcium and magnesium, that is, unless the ratio of soluble sodium to soluble calcium plus magnesium is greater than 1/1. Where the carbonate ion is an important constituent of the accumulating salts, calcium and magnesium will be in low concentration because of their tendency to precipitate as very slightly soluble carbonates (Hausenbuiller 1972). Because bicarbonate anions convert easily to carbonate, soil bicarbonate salts are not common in soil. Calcium carbonate solubility decrease with rising temperature (Birkeland 1974), so precipitate build-up during summer may accelerate due to increased temperatures as well as increased evaporation. Similar to sodium increase, carbonate build-up in the soil can reduce hydraulic conductivity and decrease the downward movement of water.

Excess exchangeable sodium is harmful to plants principally because it induces undesirable physical and chemical conditions in soils. One effect results from the dispersion of clay, which lowers the permeability of the soil to air and water. Dispersion also results in the formation of dense, impenetrable surface crusts that greatly hinder the emergence of seedlings.

A second effect of exchangeable sodium is on soil pH. Because of the ease with which exchangeable sodium hydrolyzes, sodic soils low in neautral salts often have a pH as high as 10. Whereas strong alkalinity cause little direct harm to plants, it frequently results in lowering the availability of some nutrients. Examples are iron, manganese, calcium, and magnesium (Hausenbuiller 1972). As cation content incrases, exchange sites in the soil matrix are reduced and hydroxyl (OH-) concentrations and pH increase. The alkalinity will depend on the strength of the bvase formed. For examples, Ca(OH)2 is formed in the presened of caCO3 and the resulting pH can approach 8.5. In contrast, NaCO3 and NaHCO3 form NaOH, a stronger base, and this results in Ph over 8.5 (Birkeland 1974).

The high pH of sodic soils cause soil organic matter to dissolve. If the dissolved organic matter is carried upward by the capillary rise of water, it may be deposited as a dark incrustation on the surface of the soil. When present, a dark-colored surface film is usually indicative of a sodic-soil condition. However, many sodic soils lack this particular feature, so it is not a universal diagnostic property.

Unlike the dispersive effect of exchangeable sodium, salts such as calcium carbonate and calcium sulphate flocculate colloidal matter in soils. Saline-sodic soils therefore tend to appear in a beter physical state than do nonsaline-sodic soils. In addition, if the salts are neutral, they suppress the hydrolysis of exchangeable sodium and thereby prevent the soil from having an excessively high pH. Under some circumstances, the pH of saline-sodic soils is no higher than 8.5 However, although neutral salts improve the physical state and lower the pH of sodic soils, they do not improve overall conditions for plant growth. If the salts are removed, as by leaching or precipitation, the characteristics associated with disperse clay and a high pH quickly reappear (Hausenbuiller 1972).

Soil Physical Properties

The term clay carries several connotations, which are not necessarily mutually consistent. In daily language, it suggests a soil that tends to retain water and to become soft and moldable when wet. In a more exact sense, in the context of soil texture, it designates a range of particle sizes, namely particles smaller than 2 micrometers, or a soil material in which this particle-size range predominates. Finally, in the mineralogical sense, it refers to a large group of minerals, many of which occur in the clay fraction of the soil. That fractions differs from the sand and silt fractions not only in particle-size range, but also in mineralogical composition. Sand and silt consist mainly of weathering-resistant primarily minerals, i.e., minerals present in the original rock from which the soil was formed, whereas clay includes secondary minerals formed in the soil by decomposition of the primary minerals and their recomposition into new ones.

The numerous clay minerals exhibit great variations in prevalence and properties, and in the way they affect soil behavior. Rarely do any of these minerals occur in homogeneous deposits, and in the soil they generally occur in mixtures, the specific composition of which depends in each case upon the nature of the soil forming processes. The types of clays found in the soil, the addition of salts, and the degree of saturation of the soil, all affect the chemical and physical environment of the soil. Dispersion of the clay particles can lower hydraulic conductivity in the soil, but may make the soil more susceptible to erosion as they clays dissolve and remain in solution. Physical changes in the soil as a result of saturation and salt availability may make the soil more susceptible to slumping and erosion. Extremely fine particles (slimes) may build in the soil surface where soils are constantly saturated.

Electrostatically charged clay particles attract cations, with which they form a diffuse double layer. This process of imbibition, causing swelling, is especially pronounced when the ambient solution (that is, the soil solution away from the particle surfaces) is the more dilute. Imbibition between clay platelets is constraint by interparticle bonds, and usually ceases at ambient solution concentrations above 200-400 meq/liter. With more dilute solutions, continued swelling - to relieve the osmotic pressure differential between the clay domains and the ambient solution - weakens the interparticle bonds. A combination of this osmotic swelling with mechanical disturbance of the soil system can lead to a rupturing of interparticle bonds, so that adjacent particles separate and the clay fraction undergoes dispersion, which in turn alters the geometry of soil pores and results in a decrease of intrinsic permeability.

Combinations of low salt concentration and high exchangeable sodium percentage are the conditions most likely to cause swelling, dispersion, and reduction of permeability. The collapse of aggregates resulting from dispersion of clay tends to plug the large interaggregate pores, particularly in the top layer, so that and "open" surface can become sealed. Moreover, dispersed particles can move with percolating water and migrate into the soil profile. Evidence of such migration can be seen in the occurrence of clay skins over aggregates deeper in the profiles and in the natural deposition of clay in formation of distinct layers called clay pans (Hillel 1980).

Effects of Salts on Soils and Plants

The main effect of soluble salts on plants is osmotic, since high salt levels make it difficult for the plant to obtain water for growth. The plant root contains a semi-permeable membrane permitting water to pass but rejecting most of the salt. Thus, water is osmotically more difficult to extract from increasingly saline solutions. Plants growing on saline media can somewhat increase their internal osmotic concentrations by production of organic acids or uptake of salts. This process is called osmotic adjustment. The effect of salinity on the plant appears primarily to be energy diversion from growth processes in order to maintain the osmotic differential.

One of the first processes from which growth energy is diverted is cell elongation. Leaf tissue cells continue to divide but do not elongate. Direct sensitivity to exchangeable or soluble sodium is more apparent at low salt (non-sodium salts) levels, and therefore is difficult to differentiate from the effects of sodium on soil permeability. For plants that are extremely sensitive to sodium, as little as 5% exchangeable sodium may lead to toxic accumulations of sodium in leaf tissues (Bohn et al 1979).

Recommendations

Preliminary assessment suggests that sodic soils are developing in Burger Draw, clay dispersion and mass transport are occurring, and vegetation is being lost. It is suggested that pot studies be conducted in the laboratory to ascertain the effect of produced water on semi-aquatic vegetation. These pot studies should also include the addition of various amendments such as "Envirozyme" to ascertain if soil conditions can be economically ameliorated. Suggested species for the pot studies include prairie cordgrass, Nebraska sedge, western wheatgrass, and inland saltgrass. Various soil saturation regimes should be tested, as well. Pot studies should be supplemented by field studies that include ponding and diversion of water to ascertain if water movement is playing a role in vegetation impact.

Clay mineralogies for the surface substrate in Burger Draw should be determined to aid in management strategies. The impact of produced water on clay aggregation and dispersion should be investigated. Field information should be obtained to ascertain if changes in surface soils are increasing mass movement in the drainage.

A small team composed of an experienced pedologist, a geomorphologist, a revegetation specialist, and a range conservationist should be assembled to develop the details of a study plan. Information from the study can be used to fine tune discharge practices in Burger Draw. The information gained from this study is likely to have wide application in the Basin, and thus be of interest to several stakeholders.