

Frequently Asked Questions

Saline and/or Sodic Water and Soils

Table of Contents

INFORMATION ON SALINE AND/OR SODIC WATER

[What is saline water and why is it defined as saline?](#)

[What is sodic water and why is it defined as sodic?](#)

[Can a water source be both saline and sodic?](#)

[What causes a water source to be saline or sodic?](#)

[What is a saline seep?](#)

[What is water alkalinity?](#)

[What is the salinity of rivers and streams in Montana?](#)

[What is the relationship between stream flow and EC, and between stream flow and SAR?](#)

INFORMATION ON SALINE AND/OR SODIC SOILS

[What causes a soil to be saline and/or sodic?](#)

[How do I measure soil salinity and sodicity?](#)

[What is an adjusted SAR?](#)

[How do I know if I have a problem with saline and/or sodic soils?](#)

[Where do saline and sodic soils occur in Montana?](#)

SALINITY, SODICITY, AND CROP PRODUCTION

[What are the common problems or difficulties with the use of saline water for irrigation?](#)

[What are the tolerances of common Montana crop and forage species to saline irrigation water?](#)

[How does saline water affect alfalfa growth?](#)

[What's a recommended irrigation strategy to reduce salt injury to seedlings?](#)

[What are the common problems or difficulties with the use of sodic water for irrigation crops?](#)

[What are the guidelines for the suitability of irrigation water quality relative to soil dispersion, crusting, and swelling?](#)

[What is the suggested range in EC and SAR of irrigation water for soils of varying textures?](#)

[How often and when should one measure the EC and SAR of irrigation water?](#)

[How often should one measure the EC and SAR of soil in a crop field?](#)

[Are there enforceable standards or thresholds for salinity and sodicity of water used for irrigation?](#)

[What is the best strategy for irrigating with water from rivers and streams in semi-arid areas that flow high in the spring and may even go dry in mid-summer?](#)

[Is there a threshold stream flow at which one should stop irrigating?](#)

How can one safely use saline water for irrigation?

How long does it take for the effects of irrigation with saline water to be evident in the soil?

RECLAMATION OF SALINE AND/OR SALTY SOIL AND WATER

What can be done to manage or reclaim a saline or sodic soil?

Can anything be added to saline and/or sodic water to "treat" (or clean) the water?

Will elemental sulfur or gypsum reclaim a saline and/or sodic soil?

INFORMATION ON SALINE AND/OR SODIC WATER

What is saline water and why is it defined as saline?

Water is classified as "saline" when it becomes a risk for growth and yield of crops. Saline water has a relatively high concentration of dissolved salts (cations and anions). Salt is not just "salt" as we know it - sodium chloride (NaCl) - but can be dissolved calcium (Ca²⁺), magnesium (Mg²⁺), sulfate (SO₄²⁻), bicarbonate (HCO₃⁻), Boron (B), and other compounds.

Salinity of water is referred to in terms of total dissolved solids (TDS), but salinity is actually approximated by measuring the electrical conductivity (EC) of water, expressed in decisiemens per meter (dS/m) or less often in millimhos per centimeter (mmhos/cm) (the two measurements are numerically equivalent). TDS is related to EC by the following equations:

- TDS (parts per million, ppm or milligrams per liter, mg/L) = 640 x EC (dS/m)
- TDS (milliequivalents per liter) = 10 x EC (dS/m)

The U.S. Department of Agriculture defines water with an EC greater than 4.0 dS/m as saline. The horticulture industry frequently uses a standard of 2 dS/m to define saline water.

What is a sodic water and why is it defined as sodic?

Sodic water is high in sodium (Na⁺) concentration relative to concentrations of calcium (Ca²⁺) and magnesium (Mg²⁺). The sodicity of water is expressed as the sodium adsorption ratio (SAR),

$$\text{SAR} = \text{Na} / \sqrt{[(\text{Ca} + \text{Mg}) / 2]} \quad (\text{These values are in meq/L})$$

$$\text{SAR} = (\text{Na} \times 0.043) / \sqrt{\{[(\text{Ca} \times 0.05) + (\text{Mg} \times 0.083)] / 2\}} \quad (\text{These values are in ppm or mg/L})$$

Sodic water is defined as having a SAR greater than 12.

Can a water source be both saline and sodic?

Water can be both saline and sodic, or saline-sodic. If water has an EC greater than 4 (2 for horticulture) and a SAR greater than 12, it is considered saline-sodic.

What causes a water source to be saline or sodic?

Water can naturally become saline or sodic by coming into contact with soil or geologic material that is high in salts. Upon contact, salts dissolve into the water, raising the EC and/or the SAR of the water. Water can also become saline when evaporation concentrates naturally occurring salts.

What is a saline seep?

If water is introduced to an upland site in a watershed and is not removed by plant uptake, it could move below the root zone, travel down slope, and surface at a low spot in the watershed. In some geologic formations (especially in soils formed from glacial till or stratified marine deposits) water percolating through the soil dissolves salt from the soil. Once the water reaches a compacted layer or a zone of much greater horizontal conductivity, it can move laterally until it surfaces at a low spot in the watershed either as saline potholes or seep sites. This process is called saline seep. For more information, see the [Montana Department of Natural Resources and Conservation](http://www.mt.gov/nrc/).

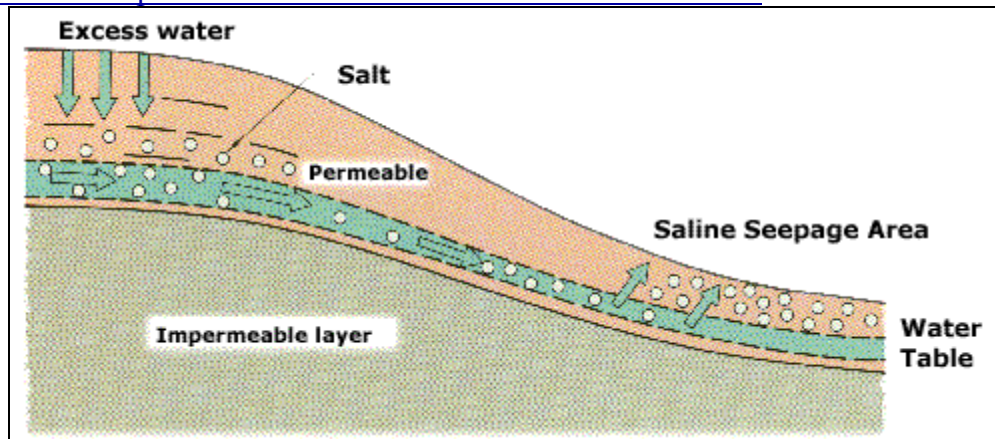


Figure source: www.agr.gc.ca/pfra/pub/prairiesoils_e.htm

What is water alkalinity?

Alkalinity is the ability of water to neutralize acids or buffer the water from change in pH. Alkalinity is measured by determining the concentration of bicarbonate (HCO_3^-), carbonate (CO_3^{2-}), and hydroxide (OH^-) and is reported as the concentration of calcium carbonate (CaCO_3) equivalent to the sum of the carbonate, bicarbonate and hydroxide. Well-buffered surface water systems have alkalinity of 20 to 300 ppm. Commercially available meters or test strips can be used to test alkalinity.

What is the salinity of rivers and streams in Montana?

In surface water systems (rivers, lakes, streams, etc.), the TDS varies from as low as only a few hundred parts per million (or milligrams per liter) in many western mountain areas, to as much as 2500 to 3000 parts per million (mg/L) during the lowest flow periods in some of the smaller prairie streams of eastern Montana. If you are interested in variability in TDS of a stream in your area, the [United States Geological Survey](#) has an extensive database of historical water quality information on streams and rivers across the U.S.



What is the relationship between stream flow and EC, and between stream flow and SAR?

Generally, salinity decreases as stream flow increases and increases with decreasing stream flow. The same is true for SAR. In many high plains streams, salinity may rise with the first flush of runoff water due to bank flushing, which washes salt off the soil adjacent to streams. Stream flow generally decreases after spring snow melt and runoff from higher elevations ends. When the river goes through rising and falling stages due to rain (especially thunderstorms), the EC is usually lower when the river level is falling, rather than rising. For a good report on this topic read the USGS Publication "[U.S. Geological Survey Monitoring of Powder River Basin Stream Water Quantity and Quality.](#)"

The EC of stream water may also increase during periods of drought and during the irrigation season from addition of irrigation return flow.

The SAR of a stream is dependent on the amount of sodium in the stream relative to the amount of calcium and magnesium. If sodium is a significant component of irrigation return flow, the SAR of the stream could increase during low flow. Similarly, if evaporation is extensive, this may also cause SAR to increase due to concentration of salts and precipitation of calcium as limestone.

INFORMATION ON SALINE AND/OR SODIC SOILS

What causes a soil to be saline and/or sodic?

Saline soils are indicative of inadequate drainage to leach salt from the soil or upward migration of salt from shallow ground water. Sodic soils have an abundance of sodium. Some soils are naturally saline and/or sodic. If the soil was formed on parent material high in salts, such as marine deposits, and it has inadequate drainage, the soil will be high in salts as well.

Soils can become saline and/or sodic from unnatural processes as well. Fertilizers, soil amendments (gypsum or lime), and manure may contribute to soil salt problems. Applications of saline and/or sodic water without adequate leaching or in the presence of a high water table will increase soil EC over time, eventually resulting in saline soil. Soils can also become saline through the process of saline seep.



Poorly drained soils, such as near a stream or river plain, can become saline and/or sodic over time, especially under irrigation or in the presence of abundant water or shallow water tables. Careful attention must be paid to management to avoid accumulation of salts where net water movement is upward due to rising water tables, excessive evaporation, or excessive plant water use without drainage.

How do I measure soil salinity and sodicity?

It is generally agreed upon among soil scientists that salinity of the soil saturated paste extract most closely represents conditions faced by plants. The general guideline is that the soil saturated paste extract will be equal to between 1.5 and 3 times the salinity of the applied irrigation water and generally will be less saline than what the plant is exposed to.

The device used to measure salinity of water is an EC meter. With the right soil water mixtures, they can be used to measure salinity of soil as well. However, only a lab can measure the sodicity, or SAR, of irrigation water. Your local [county Extension](#) or United States Department of Agriculture, Natural Resource Conservation Service ([USDA-NRCS](#)) offices will have information on purchasing or borrowing meters, as well as information on labs in your area.

What is an adjusted SAR?

The SAR of groundwater and soil water may need to be adjusted to account for changes in the chemistry of the water when it comes in contact with soil. This change can be caused by calcium precipitation. The actual concentration of calcium in soil water may be

lower (or sometimes higher) than that of the irrigation water. In soils, dissolved calcium ions will become insoluble in the presence of the carbonate (CO_3^{2-}) in the applied water. Calcium and carbonate combine to form limestone. Thus, following irrigation, the concentration of soluble calcium in the soil might be lower than that of the irrigation water. It is generally safe to assume that the SAR experienced by the soil will be 10-25% greater than the SAR of the irrigation water, due primarily to calcium precipitation.

How do I know if I have a problem with saline and/or sodic soils?

Often the problem is obvious. Excess soluble salts will often crystallize on the surface of fallow fields, while thin, patchy salt crusts will form under clods or on the shady side of clods where marginal salt problems are found. Thick, continuous crusts form in saline seeps. Saline soils tend to inhibit germination and emergence of plants. Therefore, patterns of growth in cropped fields will be poor, with spotty stand establishment. Under severe salt stress, herbaceous crops appear bluish-green; leaf tip burn and die-off of older leaves in cereal grains can result from salinity or related drought stress.



Where do saline and sodic soils occur in Montana?

The most common locations to find saline soils are in the eastern and central part of Montana and in poorly drained areas north of the Missouri River. Naturally saline soils are found along many stream terraces and bottoms, while saline seeps can be found throughout most of the glaciated plains region. Sodic soils occur in many of the same locations as saline soils, found most commonly in eastern and north central Montana and along irrigated flood plains of many rivers.

SALINITY, SODICITY, AND CROP PRODUCTION

What are the common problems or difficulties with the use of saline water for irrigation?

Saline water reduces plant growth, making irrigation with it risky if not managed properly. With time, salts carried in saline water may accumulate in the root zone to concentrations high enough to affect crop growth by reducing availability of water. Just 1 acre-foot of irrigation water of moderately saline quality ($\text{EC} = 2 \text{ dS/m}$ - the upper end of suitability for irrigation water) will introduce 1.8 tons of salt per acre of land. Soluble salts do not leach as readily in fine textured soils as in sandy soils; therefore, it is critical to add enough water to meet crop water requirements and to maintain net downward movement of water through the soil.

What is the tolerance of common Montana crop and forage species to saline irrigation water?

Table 1 illustrates salt tolerance levels for some common Montana crops.

Table 1. Salt tolerance for common Montana crops.

	Tolerant ¹ EC = 10-16	Semi-Tolerant ¹ EC = 4-10	Sensitive ¹ EC < 4
Crops	Barley Sugar beet Sunflower	Wheat Oats Safflower Corn	Potatoes Field bean Peas Lentils
Forages	Tall wheatgrass (Alkar) Bearless wildrye (Shoshone) Altai wildrye (Prairieland) Slender wheatgrass (Revenue) Western wheatgrass (Rosana) Russian wildrye (Commercial) Barley (Steptoe)	Yellow sweetclover (Commercial) Alfalfa (ladak 65) Tall fescue (Kenmont) Wheat (hay) Orchardgrass Cicer milkvetch Crested wheatgrass (Nordan)	White clover Meadow foxtail Alsike clover Red clover Ladino clover

Source: MSU Extension Montguide #8382 *Salinity Control Under Irrigation* and MontGuide MT8321 "Salt Tolerant Forages for Saline Seep Areas"

¹Electrical Conductivity (dS/m)

How does saline water affect alfalfa growth?

Saline water reduces plant growth to varying degrees, with grass and grain crops generally showing less sensitivity and field crops being most sensitive. Aside from biomass reduction, salinity can have additional effects on plants. For example, in a study by Bauder et al., both inoculated and non-inoculated alfalfa were grown with irrigation waters of progressively higher salinity levels (Figure 1). Alfalfa nodulation (ability to fix atmospheric nitrogen) was reduced and actual weight and number of nodules decreased when plants were irrigated with moderately saline water. Growth of alfalfa plants was also inhibited, even with nitrogen fertilizer application.



Growth of alfalfa decreased linearly with each increase in irrigation water salinity. Increasing salinity of irrigation water caused a greater decrease in yield for non-inoculated alfalfa than for inoculated alfalfa.

What's a recommended irrigation strategy to reduce salt injury to seedlings?

On new plantings of grass, legumes, small grains, corn, and sorghum, shorten the set times early in the season when plants are small, and irrigate more frequently. Maintaining a fairly moist soil during early growth will result in a better stand, better early growth, and an increase of as much as 25% in overall yield.

What are the common problems or difficulties with the use of sodic water for irrigation of crops?

Elevated sodium and chloride concentrations in water can harm some woody plants due to direct toxicity as ions are taken up by the root cells or applied directly to the leaves. Either way, ions can accumulate in the leaves, causing burn along the outer leaf edges. In addition, sodium can indirectly affect crop growth by causing calcium, potassium, and magnesium deficiencies or by adversely affecting soil physical properties.

In addition to being a salinity component of irrigation water, sodium poses a more troublesome problem in soils containing more than 30% of a swelling type clay. On such soils, sodium changes soil physical properties, leading to poor drainage and crusting, which can affect crop growth and yield. Irrigation with sodic water on sandy soils does not cause crusting and poor drainage, as the sodium is more readily leached from the soil profile. However, if the water is saline-sodic, crop growth and yield may be compromised on sandy soils.

What are guidelines for the suitability of irrigation water quality relative to soil dispersion, crusting, and swelling?

Table 2 illustrates guidelines for irrigation water quality relative to risk of soil dispersion, crusting, and swelling.

How to use this table: the three pieces of information you will need are: 1) the amount and type of clay in your soil; 2) the salinity (EC) or TDS (mg/L) of your irrigation water; and 3) the SAR of your irrigation water. If your soil has less than 30% clay or does not contain a swelling-type clay, risk of dispersion, crusting, and swelling caused by irrigation water is minimal. To determine risk, first select the SAR range which applies to your irrigation water, i.e., 0-3, 3-6, or 6-12. Within that range, select the EC or TDS that applies to your irrigation water. Then read across the row for the SAR x EC or TDS combination to the far right column, which indicates the risk of soil dispersion, crusting and/or swelling.

Table 2. Water quality guidelines for risk of dispersion, crusting and swelling of soils which are more than 30% swelling clay.

Major Parameter			
SAR	EC (dS/m or mmhos/cm)	TDS (mg/L or ppm)	¹ Risk of Soil Dispersion, Crusting, Swelling
0-3	less than 0.2	less than 128	Very High
	0.2-0.7	128-428	Moderate
	greater than 0.7	greater than 428	Low
3-6	less than 0.3	less than 192	Very High
	0.3-1.2	192-768	Moderate
	greater than 1.2	greater than 768	Low
6 - 12	less than 0.5	less than 320	Very High
	1.9-0.5	320 - 1216	Moderate
	greater than 1.9	greater than 1216	Low
12 - 20	less than 1.3	less than 832	Very High
	2.9 - 1.3	832 - 1856	Moderate
	greater than 2.9	832-1856	Moderate
20 - 40	less than 2.9	less than 1856	Very High
	2.9 - 5.0	1856 - 3200	Moderate
	greater than 5.0	greater than 3200	Low

Values of EC in dS/m are numerically the same as mmhos/cm; multiply by 1000 to get equivalent values for umhos/cm. TDS = total dissolved solids, which is equal to EC x 640; values are parts per million (ppm) or mg/L.

Source: Western Fertilizer Handbook Table 2-5 and Figure 2-6.

¹Risk of dispersion, swelling, and crusting applies especially to soils with more than 30% clay: clay loam, silty clay loam, sandy clay loam, or silty clay textural classes.

What is the suggested range in EC and SAR of irrigation water for soils of varying textures?

Table 3 lists suggested ranges in irrigation water EC and SAR for different soil textures.

Table 3. Suggested ranges in irrigation water EC and SAR for different soil textures.

Clay Content	Soil Texture	EC (dS/m)		SAR	
		Flood	Sprinkler	Flood	Sprinkler
Less than 30%	very coarse (sand, loamy sand)	0 - 4	0 - 5	N/A	N/A
Less than 30%	coarse (sandy loam)	0 - 3	0 - 4.5	12 - 15	12 - 15
Less than 30%	medium (loam, silt loam)	0.2 - 2.5	0 - 3	12 - 15	12 - 15
Greater than 30%	medium fine (clay loam, sandy clay loam)	0.5 - 2.9	0.3 - 2.9	6	12
Greater than 30%	fine (silty clay loam, clay, sandy clay, silty clay)	0.5 - 1.9	0.3 - 2.9	6	9

Source: Modified from Western Fertilizer Handbook

How often and when should one measure the EC and SAR of irrigation water?

The timing and frequency of measuring the EC and SAR of irrigation water really depend on the flow and cycle of the water source. If the water source is constant (such as a well, lake, pond, or large river), the water should be tested at a minimum during the lowest flow volume when water is to be used for irrigation and at the beginning of the irrigation season. If the source is a cyclic stream or river, the water should be tested any time flow has been low and stable for a long period of time. The best rule of thumb is to measure when flow is representative of irrigation water or when there has been a significant change in flow.

How often should one measure the EC and SAR of soil in a crop field?

Because sodium affects soil textures differently, it is necessary to have the soil sent to the lab for a texture analysis of percent sand, silt and clay. This analysis need only be done one time. If the soil or irrigation water is of marginal quality, the soil should be tested annually for EC and SAR prior to crop planting (have the lab test EC and SAR while they test for nutrients). Data should be compared to previous years to determine the trend of EC and SAR over time. If proper management practices are being performed, the trend

should be downward or constant. For more information on soil sampling and for a list of soil testing labs in your region, go to [MSU Nutrient Management Information](#) web site. Select "Module 1: Soil Sampling and Laboratory Selection" and refer to page 8.

Are there enforceable standards or thresholds for salinity and sodicity of water used for irrigation?

There are no Federal standards for irrigation water quality enforceable by law. Even in the case of surface water bodies designated for irrigation use under the Clean Water Act, there are no enforceable numerical salinity standards. There is only a recommended threshold of EC and SAR for irrigation water suitability. In some cases, enforceable standards are being developed as part of the Total Maximum Daily Load (TMDL) process under the Clean Water Act or because some other condition necessitates standards.

What is the best strategy for irrigating with water from rivers and streams in semi-arid areas that flow high in the spring and may even go dry in mid-summer?

First, review all available flow and water quality data (start with the [United States Geological Survey](#) web site or contact your state water quality agency), or begin collecting your own flow and water quality data. A review of the historic water quality and flow records should indicate several changes throughout the year. Knowledge of these changes may help you manage the irrigation water. In addition to testing irrigation water for EC and SAR (see previous question) use the following guidelines when irrigating:

1. Fill the profile as early as possible after the peak flow stage, or as soon after forage harvest as possible. During peak flow, salinity levels are low, but sediment is high. Sediment generally tends to decrease dramatically after peak flow.
 2. If at all possible, delay irrigation until after the peak flow period. Begin irrigating as the flow level starts to drop. Salinity and sediment levels tend to be lower on the falling stage than the rising level of the stream cycle.
 3. Some sediment in the water will help move the advancing wetting front across border-dike, graded border, basin, and furrow irrigated fine sandy loam soils.
-

Is there a threshold stream flow at which one should stop irrigating?

There is no minimum flow at which one should stop irrigating. A person should measure the EC of the water to determine irrigation suitability.

How can one safely use saline water for irrigation?

Modestly saline water can often be used successfully in the right soil x crop combination without hazardous long-term effects on the crops or soils. However, certain conditions need to be met:

- The soil being irrigated must be well-drained.
- Salt tolerant crops (established alfalfa, barley, sorghum, sudan grass, sordan) should be grown.
- Rotations should be planned to provide for a sequence of progressively more salt tolerant crops.
- Salts should be leached out of the soil in the spring or winter.



As salinity of either the irrigation water or soil solution increases (with prolonged crop water use and through the irrigation season), the volume of irrigation water applied should be progressively increased.

Adoption of new crop and water management strategies can further facilitate use of saline water for irrigation. One strategy is to substitute more saline water (later in the irrigation season) for good quality water to irrigate certain crops in the rotation or well-drained soils. Salt buildup that occurs from irrigating with saline water can be reduced in the following winter or spring from rainfall or irrigation with low-salinity water.

Soils do not usually become excessively saline in a single irrigation season. It often takes several seasons to affect the salt level in the soil. The maximum soil salinity in the root zone that results from continuous irrigation with saline water does not occur when salty water is used only a fraction of the time.

How long does it take for the effects of irrigation with saline water to be evident in the soil?

Soils do not usually become excessively saline from use of saline water in a single irrigation season. It may even take several irrigation seasons to affect the level of salt in the soil solution. The maximum soil salinity in the root zone that results from continuous irrigation with saline water does not occur when salty water is used only a fraction of the time.

The only way to be certain of the impacts of saline irrigation water on the soil is to periodically sample and test the water and the soil. Although soil testing will provide a general guideline of the effect irrigation water might be having on soil quality, the chemistry of the soil will only reflect the chemical content of irrigation water after

several cropping seasons. Irrigators should realize that groundwater quality can change with time and surface water quality changes seasonally; surface water tends to become more saline as stream flow declines. If an irrigator is going to sample water for testing, the sample should be collected after the well or supply has been pumped for some time and the sample should be placed in a clean container.

RECLAMATION OF SALINE AND/OR SALTY SOIL AND WATER

What can be done to manage or reclaim a saline or sodic soil?

Reclamation of saline or sodic soils can be done. It is first necessary to know whether the soil you want to reclaim is saline, sodic, or both, since reclamation procedures are different for each.

Saline soil reclamation requires as a minimum: 1) assessment of the problem, 2) enhanced drainage, and 3) a relatively salt free water supply. Without these components, reclamation cannot progress.

Saline soil reclamation requires leaching the soil with enough non-saline water that salts are moved below the root zone. Adequate drainage is absolutely necessary for this procedure to be successful. Research in the western United States has shown that substantial water volumes are needed to leach salt from the soil. Application of reclamation water by sprinkler irrigation or repeated pulsing of small applications of water (as opposed to flood irrigation) is the preferred method, as leaching is more thorough in an unsaturated soil. Whether leaching with a sprinkler or a flood irrigation system, testing the soil for EC following treatment will help assess the effectiveness of reclamation.

Sodic and saline-sodic soils often are or will become impermeable to water. Therefore, a soil amendment in addition to water is necessary to start the reclamation process. Following the soil amendment, one can apply water in the method described for saline soils (above). The amendment, either directly or indirectly, provides a mechanism to displace sodium from the soil. Adequate drainage is then necessary for the water to move the sodium and other salts out of the system. If a soil is sodic, an alternative reclamation option is irrigation with saline water with at least 30 percent of the salt being calcium and magnesium.

Can anything be added to saline and/or sodic water to "treat" (or clean) the water?

There are no amendments, chemicals, or additives available commercially that can be added to saline water to make the salt go away. Dilution with a non-saline water or salt precipitation with an evaporation process which leaves the salt behind and traps the evaporated water can be used. Dilution of saline irrigation water is only possible if there

is a source of non-saline water with which to dilute the saline water. The evaporation and salt precipitation treatment process may not be economical or feasible with large quantities of saline irrigation water.

It is possible to alter the chemistry of sodic water by adding calcium and magnesium. This will not eliminate or reduce the sodium, but will change the ratio of sodium to other salts. The net result is more saline water; sodium salt cannot be "neutralized."

Will elemental sulfur or gypsum reclaim a saline and/or sodic soil?

Gypsum is generally added to provide a calcium source to displace sodium in the soil. (Gypsum is calcium sulfate, 22.5% calcium). For most soils in Montana east of the continental divide, the soil is already saturated with respect to calcium (as calcium carbonate or lime). Hence, adding gypsum to a soil already saturated with calcium simply elevates the concentration of calcium, favoring formation of calcium carbonate.

Elemental sulfur can be used as an amendment at high rates (500-1000 pounds per acre). On soils in Montana east of the continental divide, sulfur is added to stimulate microbial action and formation of sulfuric acid, which lowers pH. As pH decreases, lime is dissolved, and calcium and magnesium replace sodium in soils. However, without adequate drainage and good water to move the sodium out of the soil, little reclamation is gained by adding sulfur.

For further information:

[Frequently Asked Questions - Coal Bed Methane](#)

[Basics of Salinity and Sodicity Effects on Soil Physical Properties](#)

Acknowledgements:

Thank you to the following reviewers for your time in reviewing and assisting with the final publication of this document:

Gary E. Varvel
Soil Scientist USDA-ARS
Lincoln, NE

Richard T. Koenig
Extension Soil Specialist
Utah State University

April Ulery
Dept. of Agronomy & Horticulture
New Mexico State University