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G. F. Gastler
South Dakota State University

O. E. Olson
South Dakota State University

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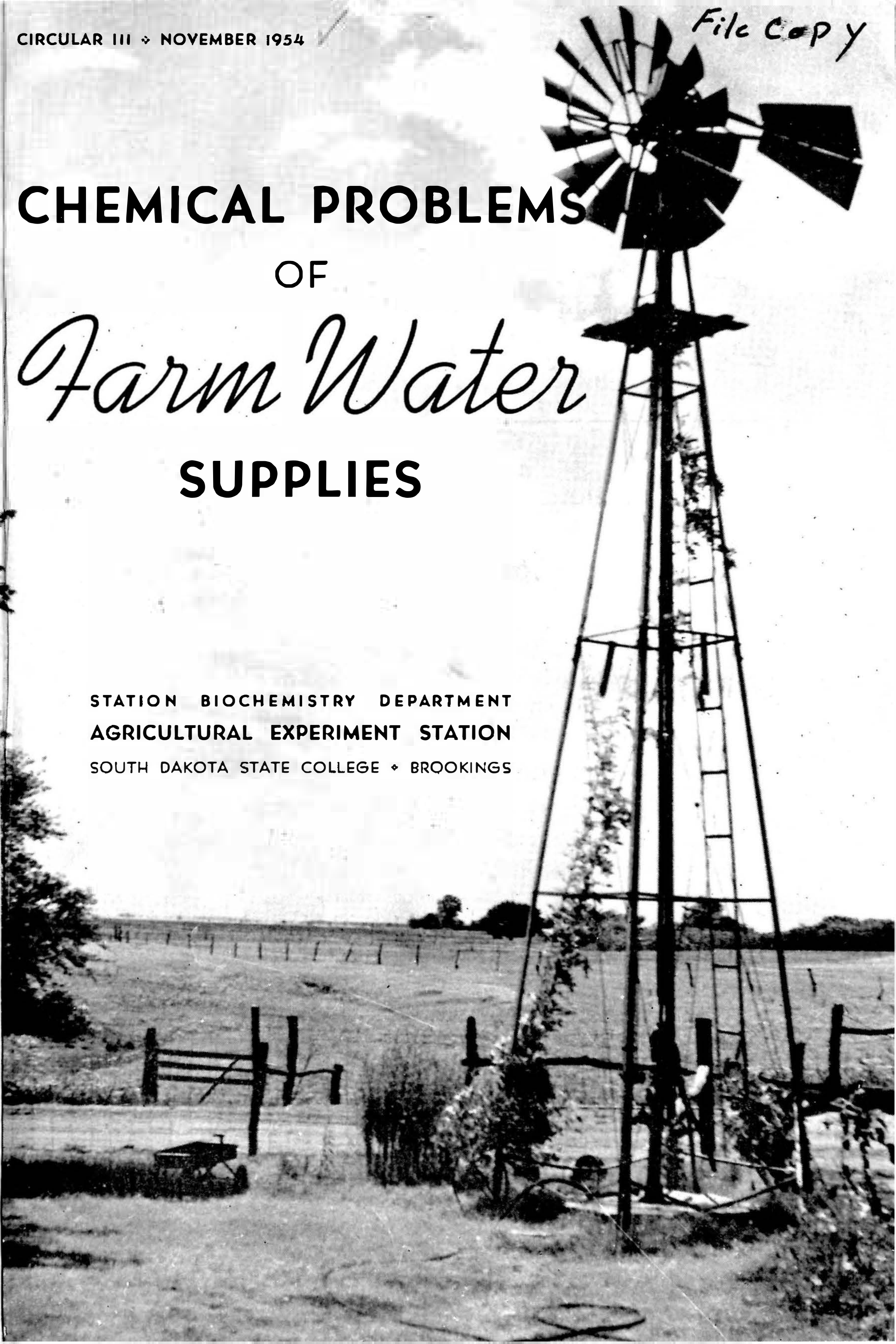
CHEMICAL PROBLEMS OF *Farm Water* SUPPLIES



STATION BIOCHEMISTRY DEPARTMENT
AGRICULTURAL EXPERIMENT STATION
SOUTH DAKOTA STATE COLLEGE • BROOKINGS

Fig. 1. Analyzing water for hardness.

Directions for Taking Water Samples

1—Use a clean bottle of at least 1 pint in size.

2—Allow the water to flow for a minute or two before taking the sample. By doing this any sediment that may have settled in the pipes is washed out.

3—Rinse the bottle well with the water (to be sampled) and fill.

4—Cap at once, pack well, and send to laboratory without delay.

5—Address and correctly identify samples sent by mail. Address of the South Dakota Agricultural Experiment Station laboratory is:

Station Biochemistry,
College Station, South Dakota

6—At the time the sample is sent, send a letter explaining the analysis desired or the reasons for which the analysis is needed. Charges are made for certain of the analyses and these can be kept at a minimum by taking only the necessary ones.

7—To sample water for a bacteriological examination (suitability for human consumption) requires many more precautions than those described. This type of analysis is discussed briefly on page 12.

Chemical Problems OF FARM WATER Supplies

G. F. Gastler and O. E. Olson[1]

The water supply on South Dakota farms is a source of many problems. In most cases, it is a difficult and expensive operation to obtain an adequate supply at a desirable location. Once obtained, many problems of plumbing and maintenance are left to be solved. Although the installation and maintenance may be expensive and difficult, the question of water quality may be even more important.

The chemical quality of the ground waters (wells and springs) of the state is variable. In a few instances, well waters containing very low concentrations of dissolved materials have been found, but most have fairly high to excessively high amounts of dissolved minerals (salts). Depending upon the use to which the water is put, these salts may or may not be objectionable.

Wells and springs, of course, are not the only sources of waters on our farms and ranches. Stock dams are widely used in many parts of the state, and the water in these does not often present problems of a chemical nature as long as it is used only for livestock. Cisterns are occasionally employed to store rain water collected from the roofs of buildings, and most of the troubles with this type of supply concern contamination with ground waters, bacterial contamination, excessive color, or bad odors. Streams, lakes, or rivers are also used, and here as in the case of ground water supplies the chemical quality is highly variable.

Since well waters are most commonly used, a large part of the discussion deals with them. However, the information is usually applicable regardless of the water source.

[1]Assistant Chemist and Chemist, South Dakota Agricultural Experiment Station.

Chemical Analysis of Water

WATERS may contain a number of chemicals, in dissolved or suspended form, which are potential troublemakers. Before going into the problems they cause, it may be well to consider what the substances are.

The Analysis

An analysis could be made for so many substances in water that it would be impossible to discuss them all here. From the standpoint of the most common chemical problems in South Dakota, however, the analysis for hardness and soluble salts or for the following would answer a majority of the questions.

Calcium	Carbonates
Magnesium	Bicarbonates
Sodium	Sulfates
Iron	Chlorides
	Nitrates

The substances in the two columns are called ions. Those on the left combine with any of those on the right to form salts. As an example, the sodium can combine with the chlorides to form sodium chloride or common table salt. Any combination of these ions results in the formation of a salt, so the value for soluble salts is an expression of the combined amounts of all ions. In water, these ions do not occur in combined form, and they must be determined separately. Carbonates and bicarbonates are often referred to as alkalinity.

The analysis is not merely a matter of testing for which of these materials are present but also for the amounts. Although recent advances in methods of testing have greatly simplified procedures, time and skill are still required to the extent that tests are made only when there is promise of the results answering some specific question.

Expression of Results

The results of a water analysis may be expressed in a number of ways. The most usual expression is "parts per million." As an example suppose a water analysis report lists the sodium at 100 parts per million (p.p.m.). This means that for every million pounds of water there are 100 pounds of sodium. Another expression that is often used is "grains per gallon." This term is usually employed in connection with hardness. It is related to parts per million in that each grain per gallon is equal to about 17.1 p.p.m.

The many ways of expressing results of an analysis are indeed confusing. However, the most important aspect of any analysis is the interpretation of results. When the chemist is given adequate information as to why the analysis has been requested he will report the results and interpret them.

Directions for taking water samples and where to mail them are given on the inside front cover.

Hardness

Hardness of water is due mostly to the calcium and magnesium it contains. Iron and certain other ions also contribute to hardness. They are generally present in such small amounts that they are seldom considered in respect to this problem. The hardness in ground waters is derived from the soils or rocks through which they percolate. In South Dakota, where soils are well supplied with calcium, ground waters are excessively hard in a majority of cases.

Damage and Losses Caused by Hard Water

When water containing calcium or magnesium is used for bathing, washing clothes or dishes, or for other household purposes, a scum is formed with the soap. This is because the calcium and magnesium react with a soap to form an insoluble compound. Hard water, therefore, requires the use of more soap, leaves rings in sinks and bathtubs, leaves a greasy surface on dishes, causes white clothes to gray on repeated washings, and decreases dirt removal in the laundry.

As hard water evaporates it deposits calcium and magnesium salts which become hard and are quite difficult to dissolve. Thus, at water faucets, in toilet bowls, and any place where such water evaporates, a crusty deposit forms which is unsightly and difficult to remove.

It is well known that when hard water is used in a tea kettle it forms a thick scale. This scale is largely the result of what is known as "temporary" hardness, also called "carbonate" or "bicarbonate" hardness. When a hard water containing bicarbonates is boiled, carbon dioxide escapes and carbonates of calcium and magnesium result. These (especially the calcium carbonate) are insoluble and precipitate to make the water cloudy or to form a hard crust (Fig. 2).

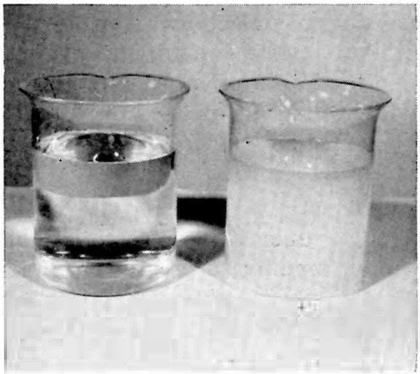


Fig. 2. A demonstration of temporary hardness. The water at the left is freshly drawn and is clear. That at the right is from the same source, but it has been boiled and the temporary hardness has come out of solution as a fine white cloud.

The same thing happens when hard water is used in boilers or water heaters, and the scale that forms greatly reduces the efficiency of heating the water. As a rule, only part of the hardness of water is "temporary." The remainder (largely calcium and magnesium sulfates and chlorides) is called "permanent" hardness. The sum of these two forms is the total hardness.

Some Remedies

Packaged softeners. Packaged water softening agents, including lye, washing soda, and a number of other compounds, have been used to a considerable extent by the homemaker for laundering and certain other purposes. Some of these products actually remove the hardness from solution causing a white precipitate. Others bind the calcium and magnesium so that they cannot react with the soap but without causing the objectionable white precipitate. Some are highly alkaline and tend to cause fabric breakdown while others are neutral in reaction or nearly so and are therefore less harmful to fabrics.

One serious difficulty with packaged softeners is in determining the proper amount to use. Instructions on the package cannot cover all hardnesses of water and each user must determine how much to add for best results. With South Dakota's very hard waters, surprisingly large amounts of these packaged softeners are required for good results. Laundering experiments conducted at this station indicate that the use of not only insufficient amounts but also of excessive amounts of these products may be detrimental, thus complicating the problem somewhat. A simple method of determining the best level of softener to add is described in the Appendix.

Detergents. Packaged detergents have a number of advantages over soaps for use in hard waters. They do not form insoluble salts with calcium or magnesium and therefore form no curd or scum. Today's detergents contain many substances such as softeners and whiteness retention agents which increase their efficiency and work well for many purposes with most waters. (Hard waters reduce their efficiency and increase the amount required.) Detergents in bar form are available for toilet purposes.

Ion exchange type softeners. The ion exchange type softener is usually the most satisfactory solution to the hard water problem. With this type, the hard water is allowed to flow through zeolite or an ion exchange resin which has been "charged" with sodium ions. The calcium and magnesium of the water displace the sodium and are retained in its place. The water is thus softened, but it contains sodium in place of the calcium and magnesium so its total salt content remains about the same. When all of the sodium has been replaced, the water is no longer softened. Ion exchange type softeners give soft water until exhausted, at which time the hardness of the emerging water rises rather suddenly to that of the untreated water.

Ion exchange type softeners will soften extremely hard water. The harder the water, however, the greater will be the required frequency of regeneration. Some waters are so hard that it is impractical to use this type of softener. No specific figure can be given for the degree of hardness above which it is impractical to soften because factors such as convenience, water usage, and economics vary so much between individual families. However, knowing the hardness of the water and the capacity of the softener, one can arrive at his own conclusions as to whether or not softening will be practical (see Appendix). Softener dealers are usually very helpful in this matter.

Ion exchange type softeners will remove a large part of the iron in water. Unfortunately, this will in time reduce the efficiency of the exchange resin or zeolite, and waters are sometimes so high in iron that the use of ion exchange type softeners is not advisable. Another constituent of water which affects the efficiency of this type of softener is the sodium content. With two waters of equal total hardness, it would be necessary to regenerate the softener more often in the water that had the most sodium. The effect of the sodium can be taken into account by determining what is called "compensated hardness" of the water (see Appendix). This sodium effect is usually not serious and has no effect on the life of the softener.

There are many brands of ion exchange type softeners on the market. They differ from each other in the kind of exchange material or mechanical or structural features. The basic principle around which they are constructed is sound and simple. In most cases, therefore, the selection of a particular make by the purchaser will depend to a large degree upon availability and certain features of construction that appear advantageous in a particular circumstance.

Finally, there are questions that arise concerning the suitability of the softened water for drinking and certain other household uses, since in the process sodium has replaced the calcium and magnesium. In general, it can be said that the taste will be changed, but this change may not be noticeable depending upon the original hardness of the water and upon the sensitivity of the taster. The taste of most softened waters is not objectionable.

The high sodium content of the softened water is objectionable in certain cases for persons on low-sodium diets. For people in a normal state of health, however, the softened water is in no way harmful. There may be differences in cooking with softened as compared to hard water, but there isn't enough work on this matter for definite conclusions.

It perhaps is best in planning a farm water system to pipe cold hard water to the kitchen for drinking and cooking since there is no reason for using softened water for these purposes (Fig. 3). Furthermore, water for outside uses such as lawn or garden watering should not be softened, since sodium salts in water for such purposes are objectionable.

Soda-lime process. In a few instances a process involving the use of lime and soda ash can be used to reduce the hardness of water on the farm. This process has been successfully used for industrial or municipal water supplies, but on the farm it has only limited application. Its main disadvantages are: (1) it requires a cistern or large tank for treating the water; (2) at best it will reduce hardness to only about 5 grains per gallon; (3) it requires filtration or a settling period; (4) it requires a chemical analysis of the water; and (5) it produces a white precipitate which must be removed. In spite of its disadvantages, a few farms have tried it when they had an unused cistern or during periods of the year when their cistern was dry.

To use this process, the chemicals in proper amounts are stirred into

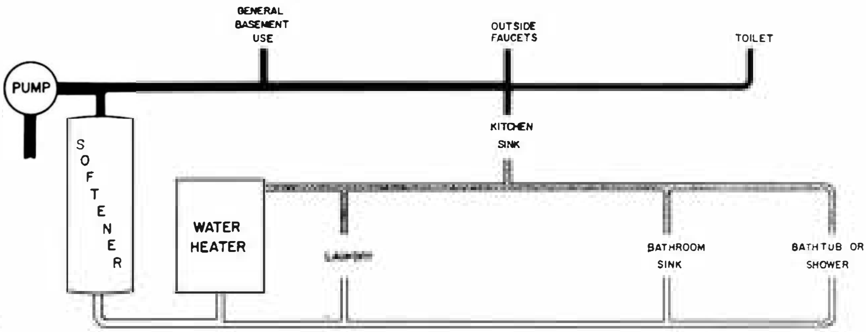


Fig. 3. A schematic plan showing one of several possible methods of plumbing the home with cold hard (black), cold soft (white), and hot soft (shaded) waters.

the water. After the water has stood for a few days, the hardness settles out as a white precipitate. The water can then be pumped off above the white sediment for use. When the tank or cistern is empty, it must be cleaned to remove the sediment before more water is treated. Under most conditions of farm use, the method should not be expected to reduce the hardness to less than 10 grains per gallon, but in many areas of the state this would be a fairly soft water.

The chemicals used in this process are inexpensive and can usually be obtained from the local drug store, elevator, or lumber yard. Analysis of the water can be obtained at the Experiment Station biochemistry laboratory for a small fee, and instructions for mixing are calculated at the lab from the analysis (see Appendix).

Iron

Soluble iron salts are present in many South Dakota waters. In this dissolved form the iron is not noticeable and the water looks clear and colorless. Upon standing in the presence of air, however, the iron becomes oxidized and forms an insoluble red to yellow colored cloud (iron hydroxide) as shown in Fig. 4. In waters of high iron content the water becomes exceedingly cloudy and upon continued standing the cloud will settle out as a red sediment.

Waters containing iron cause objectionable red or orange stains on sinks or toilets. In laundering, they cause the most trouble during bleaching. The bleach added to the water oxidizes the iron in solution to iron oxide which is deposited on the clothes to give them a yellow or tan color. This deposit is hard to remove.

Iron-bearing waters encourage the growth of certain bacteria which deposit iron on pipes and reduce the flow rates. These iron deposits may break off in large masses and cause clogging.

Iron in water, in addition to causing the problems discussed, gives it a bad taste. Small amounts, of course, will not be noticed, but much over 1 p.p.m. causes an astringency which will increase with increasing iron content. High iron waters also cause tea to turn black.

Pipes through which water travels may sometimes be the main source of the iron it contains. However, the iron present in South Dakota rural water supplies usually comes from the soils, sands, or rocks through which the water has percolated.

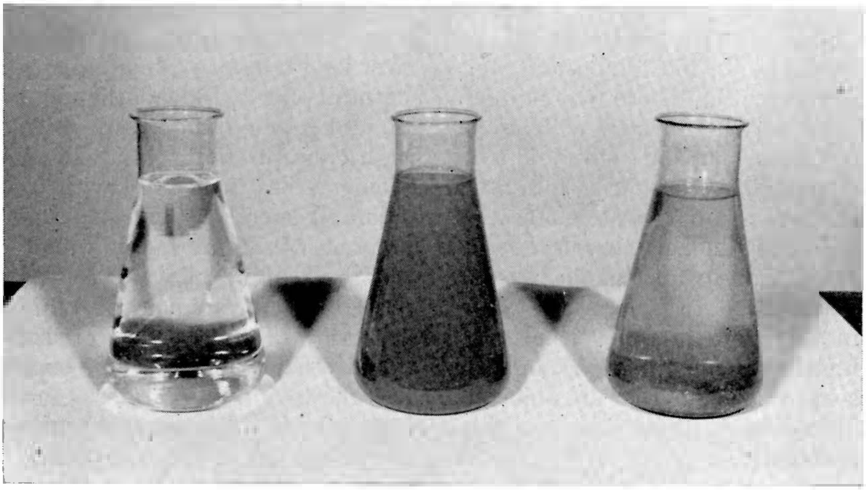
There is no easy solution to the iron problems in South Dakota farm water supplies. Some commercial iron removal equipment for home use is available, and for information concerning this one should see his local plumbing accessory dealer.

As was previously stated, ion exchange type softeners remove some of the iron from water, but with high iron waters their efficiency of softening becomes reduced. These softeners should not be purchased with iron removal in mind unless they are specially designed for that purpose and the manufacturer recommends their use on the particular water in question. In most cases, it is still necessary to "live with" the iron problem. Some suggested remedies that may be helpful in overcoming it are listed in the Appendix.

Salts

Beside the difficulties from hardness and iron, the salts in waters cause many other problems on the farm. These vary with the chemical

Fig. 4. Iron in water. The water on the left was drawn just prior to taking this picture from a source known to be high in iron. The water in the center was drawn from the same source 1 day earlier. An orange-red precipate has formed through oxidation of the iron. The water on the right is from the same source, but was taken 2 days before the picture was taken. The insoluble iron oxide has largely settled out although some of it still clings as a thin film to the sides of the flask, making it appear that the water is cloudy and colored.



nature of the water. For instance, a very hard water is also high in salts (calcium and magnesium) while some soft waters may also be high in a different type of salt (sodium). The problems with high sodium waters will also vary to some extent depending upon whether sulfates, chlorides, bicarbonates, or other negative ions predominate. Some of the instances where high salt waters cause difficulties will be discussed below.

Household Waters

Dissolved salts in water give it a flavor. Distilled water, for instance, contains no salts and has a very flat taste. Cistern water has small amounts of dissolved materials and usually it does have a slight flavor. Ground waters containing amounts of dissolved materials over a wide range of concentrations will vary considerably in taste depending upon the types and amounts of salts present.

Whether or not a water will taste good or objectionable to a person will depend to some degree upon his taste sensitivity, but what he is used to will be the most important factor in this matter. Those who normally drink very hard waters will find low salt waters flat and high sodium soft waters salty. Those used to soft waters will find hard waters objectionable. It is difficult, therefore, to set any standards for chemical composition based on taste. Many waters in this state are, nevertheless, so high in calcium or magnesium or in sodium salts that they are objectionable even to those who use them constantly.

The effect of high salt waters upon cooked foods has not been studied extensively. As far as flavor is concerned, what the person eating the food is used to will be a major factor in determining its taste qualities. However, there are indications that with many of our high salt waters, the flavor of cooked foods is affected by the nature and amount of salt present. Work on this phase of the problem is planned for the future at South Dakota Agricultural Experiment Station.

Waters of high sodium or magnesium sulfate content are laxative to those not accustomed to them. Those who use them continuously, however, become adjusted and apparently suffer no ill effects from them.

Stock Waters

A good water supply is essential for profitable livestock production. There are some cases where an adequate supply of water is available but its high salt content makes it undesirable.

Cattle and sheep are able to consume large quantities of salt daily over long periods without apparent harmful effects. Indeed, the regulation of protein intake by mixing high concentrations of salt in supplements has been used with considerable success. When such large amounts of salt are fed, however, a plentiful supply of water must be available to the animals at all times.

In view of the tolerance of sheep and cattle for salt, one would expect that they could drink water of fairly high soluble solids content without harm. Studies at other experiment stations have shown that 15,000 p.p.m. of salts in water is about the upper limit of safety, regardless of the type of salt. For lactating and perhaps for fattening animals the limit is lower than this. Hogs and chickens are somewhat less salt tolerant than sheep and cattle, and turkeys and ducks are rather susceptible to salt poisoning.

Animals on water of high salt content restrict their water intake because of its unpalatability. The restricted water intake is perhaps as harmful as the amount of salt consumed, at least with cattle and sheep. When two sources of water are available, one of which is objectionably high in salts, the animals will drink from the low salt water.

It is not possible to set rigid standards for the chemical quality of stock waters. However, using all available information Table 1 has been devised as a guide.

It should be kept in mind that tolerances for hogs and poultry are somewhat lower than for sheep and cattle. Furthermore, the salts in the ration should be considered.

A few waters have been found where nitrates were present in sufficient quantity to cause death in cattle. These were always from the shallower wells where nitrates in the soil were presumably leached and accumulated in the ground waters. Artesian wells, ponds, and stock dam waters have not been found to be concerned in this problem. The level of nitrate in water that is toxic has not been determined as yet, but experiences to date indicate that over 250 p.p.m. of nitrate nitrogen may be dangerous. Nitrate poisoning has been discussed in detail in South Dakota Agricultural Experiment Station Bulletin 424.

Irrigation

Excessive amounts of salts in waters used for irrigation are undesirable because of their effects upon the soil or upon plants. Waters high in sodium, especially as the bicarbonate are the most undesirable.

Before any irrigation program is started the water to be used should be analyzed. Such an analysis can be obtained for a small charge through the Agronomy Department of the Experiment Station. Before any sample is submitted, a letter should be sent stating that an analysis of water for irrigation purposes is wanted. Instructions for sampling and sending the water will be forwarded from the laboratory along

Table 1. Guide to the Suitability of Waters of Varying Soluble Solids Content for Livestock Use

Soluble Solids Content of Water (Salts)	Suitability for Use by Sheep and Cattle
0—1000 p.p.m.	Excellent
1000—5000 p.p.m.	Good to permissible
5000—10,000 p.p.m.	Permissible to poor
10,000—15,000 p.p.m.	Poor to unfit
Over 15,000 p.p.m.	Unfit

with a blank requesting certain information. This information is necessary in deciding upon the suitability of the water for irrigation because such factors as water usage, types of crops, type of soil, and drainage are about as important as the water analysis itself.

Sanitation and Miscellaneous Problems

Bacterial Contamination of Waters

The problem of maintaining a supply of water suitable for human drinking purposes is, of course, of great importance. Although the fitness of water for human consumption involves some chemical analysis, the problem is mainly bacteriological and will therefore not be discussed here. For information concerning water supplies in relation to human health, inquiries should be directed to the Division of Sanitary Engineering, South Dakota State Department of Health, Pierre, South Dakota.

Fluorides

In certain areas of the state, waters contain an excessive amount of fluoride. This water causes what is called mottling of teeth. On the other hand, considerable evidence has been accumulated to show that dental caries are much less prevalent in children who drink water containing about 1.0 p.p.m. of flouride. At present many cities are adjusting fluoride content of the water to about 1.0 p.p.m., but equipment for farm water supplies is not available for this purpose. Where a problem of fluoride excess or deficiency occurs in farm supplies, the family dentist should be consulted.

Hydrogen Sulfide

In a few cases South Dakota ground waters contain hydrogen sulfide. This gives the water a "rotten egg" smell. Hydrogen sulfide reacts with iron and causes a black deposit of iron sulfide to form. Aeration and chlorination have been used to remove this chemical from water but on the farm neither practice would be very practical. Waters in which the hydrogen sulfide concentration is not so high as to make them entirely unpalatable should not be harmful to man or livestock.

"Water Bloom"

The death of animals has sometimes been found to occur where the waters of small ponds containing large amounts of certain types of algae are consumed. The occurrence of these algae is known as "water bloom." The kinds of algae concerned, the nature of the poison, and the circumstances and factors leading to the production of poison in these cases are not definitely known. The occurrence of deaths from "water bloom" is rare and as far as is known does not constitute a problem of much significance.

Odors and Tastes

Water in cisterns or tanks or in unused wells may often become stagnant and smell and taste bad. These waters can be freshened by chlorination (see Appendix). Use of these waters is not recommended, however, unless the problem has had the attention and recommendations of the State Health Laboratory. For laundry or livestock, however, chlorination should yield satisfactory water.

APPENDIX

Removing Iron Stains. Rust spots or stains can somtimes be removed from clothes by moistening with lemon juice and salt and drying in the sun or by soaking in oxalic acid (poison) solution. When the stain disappears the clothes should be rinsed well with water, treated with very dilute ammonia solution, and rinsed well again.

Bluing may contain an iron compound which is affected by alkali. If some bluing is deposited on clothes and not rinsed off, heat from the sun or electric iron may cause a chemical reaction and form small spots of rust.

Iron stains on sinks or bowls are usually difficult to remove. Some commercial preparations are available for this. Mildly abrasive scouring compounds may also be used with some success. Strong acids will usually remove the stains, but they are not recommended because of their effect on the porcelain and metal parts.

Amount of Package Softener to Use. A simple method for determining the amount of package softener to use is to add ½ level teaspoon of the softener to 2½ cups of hot water in a 2 quart fruit jar. Then add 1 teaspoon of soap, cover, and shake well. If a good standing suds forms the water is soft. If not, repeat using an increased amount of softener. The number of half-teaspoons of softener required to give good results in the test is about equal to the number of tablespoons required per gallon of water.

Cause of Clothes Yellowing. Yellowing of clothes may sometimes be caused when waters high in sodium bicarbonate are used in laundry. This is because on ironing, the small amount of sodium bicarbonate left as a residue in the clothes causes the formation of an oxycellulose. The effect is very marked when sodium bicarbonate alkalinity exceeds 200 p.p.m. (expressed as calcium carbonate).

Water for House Plants. Water collected from electrically operated dehumidifiers is excellent for use in watering house plants. The same is true for water collected during the defrosting of refrigerators.

Use of Stagnant Water. Stagnant water can be freshened by treating with a chlorine bleach. One-fourth cup of liquid *chlorine* bleach should be added for each 100 gallons of water and mixed well. After standing for a few days the water should be satisfactory for laundry purposes or for stock. To treat water for human consumption, recommendations of the South Dakota Department of Health should be obtained.

Some Calculations for Ion Exchange Type Water Softeners

Compensated Hardness. Compensated hardness takes into account the effect of sodium in the water on the capacity of the softener. It may be quickly determined on the chart below. The use of the chart is illustrated by the fine dotted lines which show that for water containing 1250 p.p.m. of sodium and a hardness of 50 grains per gallon the compensated hardness is 68 grains per gallon.

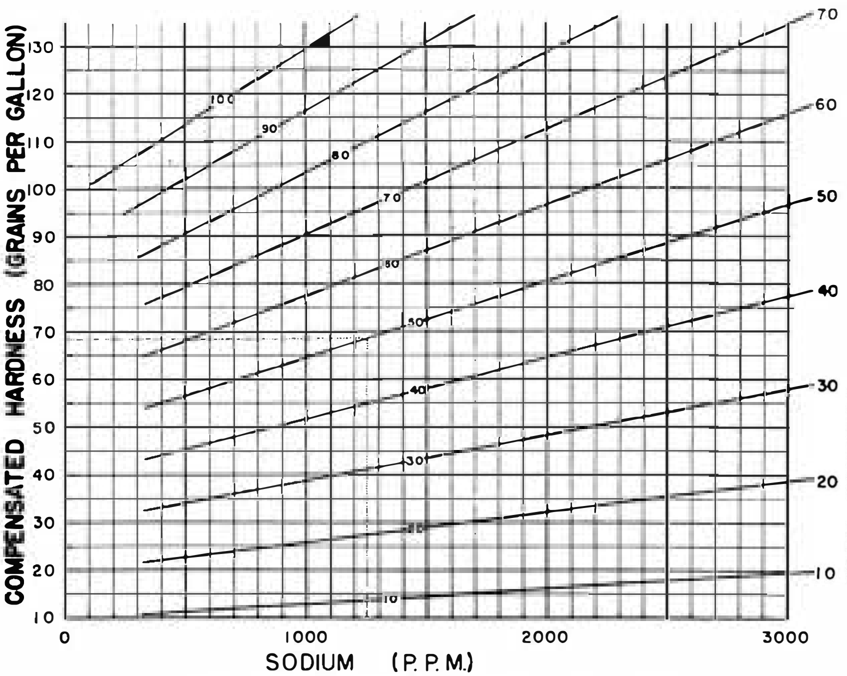


Fig. 5. Chart for determining compensated hardness.

Water Usage. The amount of softened water a family uses will depend upon many factors. About 35 gallons per person per day is a good average value. Where actual water usage is not known this figure multiplied by the number of people in the family gives an estimate of daily softened water usage.

Required Softener Capacity. Exchange type softeners are built in various sizes. In order to determine what size (capacity) to buy the following calculation should be made:

Multiply daily softened water usage by compensated hardness. (Total hardness can usually be used without causing excessively large errors when compensated hardness is not known.) The resulting figure tells how many grains of hardness a softener must remove daily. Multiply this by the number of days desired between regeneration with salt and the result gives the capacity of softener required in grains.

Example: For a family of four, compensated hardness of 30 grains per gallon, and regeneration every 21 days:

4 x 35 = 140 gallons daily
140 x 30 = 4200 grains daily
4200 x 21 = 88,200 grain capacity for softener

Reducing the Hardness of Farm Waters by the Soda-Lime Process

This process should not be expected to soften to less than about 10 grains per gallon of hardness.

1—Draw a sample of water and send to the laboratory for testing in accordance with instructions on inside front cover.

2—Determine the volume of water to be softened. The following table can be used for this.

Table 2. An Aid for the Calculation of the Volume of Water in Tanks

Diameter of Vertical Tank or Length of One Side of Square Tank	Gallons of Water per 1 Foot of Depth	
	Round Tank	Square Tank
6 feet	212	269
7	288	367
8	376	479
9	476	606
10	588	748
11	711	905
12	846	1077
14	1152	1466
16	1504	1915
18	1904	2423
20	2350	2992

3—If instructions have been followed in sending the sample for analysis, the laboratory will calculate the amount of lime and of soda ash to add per 1000 gallons of water (these chemicals should be obtainable through local merchants). The amount of chemicals needed can be calculated according to the volume of water to be softened.

Soda ash is also called by other names such as sodium carbonate or washing soda. In some forms it may contain considerable water and this must be taken into account. The recommendations of the laboratory are based on 90 percent purity.

Unslaked lime (calcium oxide) is used in this process and the calculations by the chemist are based on it. Slaked lime (calcium hydroxide) may be used instead at a rate 1.32 times as great as that calculated for the unslaked lime.

4—The following procedure is suggested for treating the water, although any method that allows for thorough mixing of the chemicals can be used:

Fill the tank or cistern to the desired level. Then weigh out the required amounts of lime and soda ash. Fill a metal pail about half full of water and add to it part of the lime, breaking up the lumps and making a thin slurry (heat will be generated). Pour the slurry into the tank or cistern and mix well. Repeat until all of the lime is used and then do the same with the soda ash. Thoroughly mix contents of the tank or cistern and allow to stand.

During treatment an insoluble material forms. This should be allowed to settle before using the water. The material that settles out should be removed before any more water is treated.

Caution: Soda ash and lime are caustic. Precautions should be taken to keep them off skin and clothes.

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